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GEOLOGIC TEMPERATURE RECORDERS

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INTRODUCTION

A QUANTITATIVE knowledge of the conditions of formation of minerals and rocks—the temperatures, pressures and concentrations involved—is naturally a matter of much concern to the geologist. At times he is able to view certain processes of mineral formation in progress and can make direct measurements of some of the conditions with the aid of the various devices that have been developed for such purposes, usually by workers in other branches of science or technology. For the measurement of temperature, which is the variable here under discussion, a great many devices are available but they uniformly depend upon one broad principle. The known rate of change with temperature of some property of a substance—volume, electromotive potential, radiation—serves as a measure of temperature. Various instruments for the direct measurement of temperature have been used by the geologist with the result that he has come to know something of the temperatures of flowing lavas, of fumaroles, of hot springs and of other geologic activities taking place at yet more moderate temperatures.

It is not to direct measurements made upon materials in process of change that attention is here directed. For measurements in connection with many technological or natural processes it may be inconvenient to have an observer continuously present, but it has proved possible to construct instruments which will furnish information as to the temperature. These vary from elaborate recorders which provide a complete, continuous record of the temperature, to the other extreme of maximum or minimum thermometers which furnish only information as to the maximum or minimum temperature attained. In reality they are, just as definitely, recorders. It need hardly be said that, whether of the elaborate type or of the simplest type, recorders depend for their use upon a foreknowledge of the change of some property with temperature. The simple maximum or minimum thermometer merely records the maximum extent of this change in the one direction or the other. In this respect geologic temperature recorders are of the same character as the simplest type of recording instrument, but in other respects they are very different, indeed they are not instruments at all.

It is manifestly not merely inconvenient but altogether impossible for the geologist to be present during most geologic processes, especially those that took place in the remote past. Any record of temperature will, for these completed processes, be obtained, not by direct observation nor yet through the agency of

any man-made recording device, but rather by seeking in the rocks themselves internal evidence of the temperatures that have existed. Such evidence must come from ascertained facts regarding the effect of temperature upon various physical properties of the minerals of the rock and upon physico-chemical properties of the mineral assemblages. *Minerals are the geologic temperature recorders.*

Nearly all man-made devices for determining temperature depend upon the measurement of some property which varies *continuously* with temperature. Occasionally it is possible to use some such property in the estimation of geologic temperatures. Thus, the change of volume which has occurred during the cooling of liquid inclusions in crystals, as determined by the relative volume of liquid and its associated gas bubble, has been taken, under certain assumptions, as a measure of the drop in temperature, from which the temperature of envelopment of the liquid by the crystal is readily obtained. Likewise the change of solubility of certain salts precipitated from such fluid inclusions, as determined by the relative quantity of salt and solution, may be a measure of the fall in temperature. Estimates of temperature based upon such considerations have but little reliability. They involve too much unverified assumption as to the initial condition of the materials and too little exact knowledge of the temperature coefficients of volume and solubility of such materials.

It is rather to *discontinuous* changes of properties consequent upon change of temperature that we must turn for indications of temperature in geologic processes. The discontinuous changes are those which ordinarily accompany "change of phase," such as melting, boiling, inversion and others. There is, of course, nothing novel in such procedure. In ordinary thermometry use is made of these discontinuities of properties accompanying change of phase; indeed, the whole thermometer scale is referred to a number of fixed points, the melting-point of water, the boiling-point of water, the boiling-point of sulfur, and so forth. The devices depending upon *continuous* changes of properties serve only to furnish arbitrary subdivision of the intervals between these fixed points. Geologic thermometry is, therefore, fundamentally of the same character as ordinary themometry; both use as reference points the temperatures of phase changes. In ordinary thermometry it is possible to choose convenient and well-behaved substances for those whose phase changes are to constitute the fixed points. But the geologist, having no such choice, is at a decided disadvantage. His temperatures must be referred to possible phase changes in the substances actually present in rocks. In addition there is, in geologic thermometry, no means of subdividing the intervals between the fixed points. The intervals should therefore be as small as possible. Ideally, the geologist should know the temperatures of all the phase changes of all minerals. Although this goal is far from attainment, such knowledge is being gradually accumulated through laboratory studies of the so-called thermal properties of minerals.

What a happy circumstance it would be for the geologist if the melting, inversion and boiling phenomena of a substance were really adequately described by the designation *thermal properties.* Unfortunately, they are *thermodynamic* properties. In all these changes there is involved, in addition to a thermal factor, a work factor, because a change of volume accompanies the change of phase, and the magnitude of the work factor depends upon the applied pressure. The temperature at which the phase change occurs therefore varies with the pressure, the effect of pressure being expressed

quantitatively in the well-known Clausius-Clapeyron equation. The variation is a matter of small concern to the physicist seeking to establish a series of fixed points on a thermometer scale, for he can define a point in terms of an arbitrary and convenient pressure, whereupon the temperature of the phase change becomes indeed a fixed point. But the geologist must take things as he finds them. He has no control over the process whereby minerals were produced, and in seeking to use the temperature of a change of phase as a "point" on a thermometer scale he must have due regard fo effect of pressure on the temperature at which the change occurs. It is sometimes possible to estimate with sufficient accuracy the superincumbent load under which mineral formation or transformation occurred, and thus to make appropriate correction to the temperature as measured under the ordinary pressure, but it is always desirable to place principal reliance upon phase changes in which the volume change is small and the effect of pressure correspondingly small. Thus equilibria between solids or between solids and liquids are generally to be preferred to equilibria involving the formation of a gas.

Having gained, by laboratory investigations, a knowledge of temperatures of various equilibrium phase changes for a wide range of mineral substances and having thus established his "fixed" points, the geologist puts them to work by examining rocks and attempting to decide from internal evidence whether its materials have passed through any of these points. The nature of the evidence varies and can only be discussed in terms of specific examples. It is always concerned with the answer to the question whether or not a certain temperature has been attained and thus is, as already pointed out, not unlike the evidence furnished by a maximum (sometimes a minimum) thermometer. With this preliminary discussion of the general character of natural temperature recorders in geology, we may pass to a consideration of some of the "fixed" points and their utility.

Melting-points

The melting-point of any crystalline substance, at a given pressure, places an upper limit upon the temperature range in which that substance can crystallize at that pressure. To be sure, this is frequently not a particularly useful fact, for the presence of other substances ers the melting-point so much that the limitation placed by the melting-point of the substance itself is altogether too wide, especially for substances of high melting-points. If we consider Table I, in which are given significant melting-points of minerals, we find that there is evidence from other considerations that such minerals as olivine have crystallized in all rocks at temperatures far below their melting temperatures, so far indeed that the melting-point is only of secondary importance as an indicator of the maximum possible temperature at which crystallization could have occurred. On the other hand, if we turn to such a mineral as native bismuth, which melts at 271° at the ordinary pressure,[1] we may say that in any deposit containing that mineral we may be sure that the bismuth and any minerals deposited contemporaneously were formed (crystallized) below 271°, and this may be very useful.

The limited utility of the minerals of high melting-point as indicators of maximum possible temperatures of their crystallization no longer obtains, of course, if the magnitude of the effects of the associated minerals is known.

[1] Bismuth, like ordinary ice and unlike most substances, contracts on melting and its melting-point is consequently lowered by increased pressure. At 3,000 atmospheres, corresponding with a depth of some 10 kilometers in the earth, it is lowered only to 260°.

TABLE I

SIGNIFICANT MELTING POINTS OF MINERALS

Olivine (forsterite)	Mg_2SiO_4	1890	Pyrrhotite	$FeS + S$	1157–1187
Enstatite	$MgSiO_3$	1557*	Galena	PbS	1120
Plagioclase (An)	$CaAl_2Si_2O_8$	1550	Argentite	Ag_2S	842
Diopside	$CaMgSi_2O_6$	1391	Stibnite	Sb_2S_3	546
Plagioclase (Ab_1 An_1)		1287–1450	Pyrargyrite	$3Ag_2S \cdot Sb_2S_3$	483
Orthoclase	$KAlSi_3O_8$	1170*	Orpiment	As_2S_3	320
Plagioclase (Ab)	$NaAlSi_3O_8$	1120	Bismuth	Bi	271
Aegirite	$NaFeSi_2O_6$	990*	Sulfur	S	119

* Minerals so marked melt incongruently.

In other words, if we know the melting-temperatures and general thermal behavior of mineral assemblages, then the properties of the assemblages can be used in the same manner as the properties of individual minerals, and lower limits can be set to the maximum possible temperature of crystallization. An enormous amount of information is, indeed, now available upon the melting-points of mineral mixtures and is used to indicate maximum possible temperatures of formation. It is not possible to present such material in brief compass, and in its details it concerns primarily the geologist rather than the physicist, who can in this connection be interested, for the most part, only in methodology.

Upon occasion the geologist may wish to know not merely the temperature at which a certain mineral or group of minerals formed, but also the temperature that may have been attained by the liquid or melt from which they formed. Information as to the temperature attained when the melt was (if it ever was) at very great depth in the earth, we may not hope to secure, but upon its temperature when it reached the position in which we now find its products we can reach rather definite conclusions. They come again from consideration of melting-points of minerals, not, to be sure, of the minerals formed from the melt, but of the minerals in foreign inclusions that have been caught up by the melt. Small inclusions must attain the full temperature of the liquid and show the appropriate effects. Solution there frequently is, but forthright melting is not common and is displayed only by inclusions made up of the more fusible minerals or mineral assemblages. The evidence points strongly toward the conclusion that the liquids or melts were not excessively hot, were, indeed, in most instances within their crystallization range.

Besides indicating the maximum possible temperature of crystallization of a mineral, the melting-point may be regarded also as the minimum possible temperature of existence of a liquid having the composition of the mineral. However, when we find a rock giving every evidence of having formed from the molten state and consisting entirely of one mineral, we should not feel compelled to conclude that it was formed from a liquid which had a temperature higher than the melting-point of the mineral. In the case of rocks consisting entirely of olivine, a temperature approaching 1,890° for the liquid would be indicated by such reasoning, but when we examine inclusions with known thermal properties in such olivine rocks no evidence is found that they have been subjected to such high temperatures. We are forced to seek an origin for such rocks other than their formation from a liquid consisting entirely of olivine substance. Either the olivine crystals accumulated from a complex melt rich in other silicates which gave it a relatively low melting range, or the liquid, with respect to its silicate content, was substantially of olivine composition but contained considerable quantities of volatile substances now lost. Upon the relative merit of these two possibilities no general agreement has been reached. It

would carry us too far into geologic minutiae to discuss the pros and cons; indeed, we have perhaps already strayed too far in that direction for present purposes, but it has been deemed advisable to discuss rather fully the geological significance of some of these melting-points before pasing on to a consideration of other types of "fixed" points.

Inversion Points

A great many mineral compounds can appear in more than one crystalline form, and the temperature at which two crystalline forms (phases) are in equilibrium is called an *inversion* point. The most useful "fixed" points in geologic thermometry are inversion temperatures and their use depends upon the observer's ability to decide (a) which crystalline form of a substance is present in the rock and (b) whether that form was originally present or whether it has developed by inversion from another form. Decision upon the first question (a) is nearly always readily made; the second question (b) must at times be left open, but can be answered frequently enough to enable the establishment of definite conclusions. And here it is important to note that inversions may be broadly classified for present purposes into two classes, the prompt and the sluggish. In the former the substance changes promptly from the high-temperature form to the low-temperature form when the temperature passes downward through the inversion point, and the reverse change takes place as readily when the temperature change is in the opposite direction. Obviously, with such a substance, if crystallization takes place above the inversion point it will invariably give the high-temperature form, and if below the inversion it will give the low-temperature form. Obviously, too, the form observed upon examination of the rock at room temperature will always be the low-temperature form; therefore, we can use the inversion point as a recorder of temperature, if we can decide by study of this low-temperature form whether it is original or whether it was formed by inversion from the high-temperature form.

The sluggish inversions present a different picture. The high-temperature form of a substance having sluggish inversion may be cooled through the inversion point without the appearance of the low-temperature form, and it may be necessary to hold the temperature a little below the inversion point for a considerable period before inversion occurs. If, instead, the temperature is permitted to fall rapidly to room temperature, the high-temperature form will persist indefinitely. If the low-temperature form is heated, its temperature may rise above the inversion point without appearance of the new form, but it is the universal experience that there is much less lag in the rising-temperature direction. From these observations, which are of course made in the laboratory under controlled conditions, it might be supposed that the sluggish inversion would be more serviceable than the prompt as a temperature recorder. The finding of the high-temperature form of a mineral substance in a rock might be regarded as indicating that the rock formed above the inversion temperature, and the presence of the low-temperature form as indicating formation below the inversion temperature. Unfortunately, the situation is not so simple for it has been observed in many substances with a sluggish inversion—and it is probably true of all such cases—that the high-temperature modification can not only persist at low temperatures but can actually form at these temperatures. The high-temperature phase thus furnishes no indications as to temperature unless there is clear evidence that the substance was originally in the low-temperature modification and was transformed into the high-temperature modification. Then there is of course, undoubted evidence

that the temperature of the material had been raised to a point above that of the inversion. The low-temperature phase has not been observed to form above the inversion and probably can not. The presence of that form is, therefore, a definite indication of crystallization below the inversion temperature, provided the evidence is clear that the low-temperature modification was not formed secondarily by inversion of the high-temperature modification, and decisive evidence on that question is usually forthcoming.

With this amount of general discussion of the character of inversion points and their utility as fixed points in geologic thermometry, we may pass to consideration of a few examples. The substance silica, SiO_2, by reason of its widespread occurrence and its crystallization in a number of different modifications, is especially useful. There are four stable forms and therefore three inversions, which are as follows at the ordinary pressure:[2]

low quartz $\rightleftarrows$ high quartz	573° C.
high quartz $\rightleftarrows$ tridymite	870° C.
tridymite $\rightleftarrows$ cristobalite	1470° C.

The effect of pressure on the first inversion has been measured.[3] It is raised 21.5° by a pressure of 1,000° atmospheres which corresponds with a depth of some 2.5 miles in the earth. The effect of pressure on the second inversion can only be calculated from approximate values of the heat effect and volume change and appears to be significantly greater than the above and in the same direction. The third inversion lies at too high a temperature to be of any significance as a fixed point, but since cristobalite is a well-known natural mineral the conditions of its formation must be considered. The first inversion is of the prompt variety, the other two are sluggish. They are therefore to be used somewhat differently, and it may be added here that inversions, like melting-points, are used for two purposes: to indicate temperatures of initial formation, and to indicate temperatures to which immersed inclusions were heated.

In virtue of what has been said of sluggish inversions, it is plain that cristobalite and tridymite should be able to form at low temperatures; indeed, they do form at low temperatures in the laboratory, and they can not ordinarily be taken as indicators of high temperature. In many occurrences there is clear evidence from other sources that they were formed at moderate temperatures far below their stable ranges. Occasionally the one or the other is found as one of the minerals of a foreign inclusion in a magma and has characters indicating its formation by inversion from quartz. In such cases the definite conclusion can be drawn that heating above at least the 870° inversion has occurred, but the formation of cristobalite can not be taken to indicate heating above 1,470° because quartz has been observed in the laboratory to change directly to cristobalite below 1,470° and without passing through the intermediate stable form, tridymite. On the other hand, an inclusion which furnished evidence that tridymite was transformed to cristobalite would necessarily have been heated above 1,470°, but such temperatures are unknown in geology except perhaps in connection with two phenomena, the formation of fulgurites by lightning and the formation of impact craters by meteorites, phenomena which are, presumably, as much geologic as meteorologic or cosmic. In some of these instances silica has thus been heated not merely above its 1,470° inversion but above its melting-point at 1,713°, possibly above its boiling-point.

In geology proper, it is the lowest stable inversion of silica that is the most

[2] C. N. Fenner, *Am. Jour. Sci.*, 36: 331–384, 1913.

[3] R. E. Gibson, *Jour. Phys. Chem.*, 32: 1197, 1928.

serviceable. This change, involving high and low quartz, takes place at 573° and is of the prompt variety. All quartz as viewed at low temperature is therefore low quartz. The problem is to determine whether it was ever high quartz, in other words, whether it gives evidence of having passed through the 573° inversion and therefore of having been formed above 573°. A number of criteria are available, based on the change of crystal form and of volume which are known to occur at the inversion. They will not be enumerated here, but by their aid it can sometimes be decided whether or not the quartz was formed above 573°. It is a very useful reference point for the crystallization of many rocks and mineral deposits.

We thus see that, although persisting metastably and at times even formed metastably, nevertheless all the principal forms of SiO_2 are found in nature, even those which are stable only at quite high temperatures. Not all substances show like relations. There are a number of substances with known high-temperature forms which have never been observed in these forms in nature. Among these is the mineral wollastonite,[4] $CaSiO_3$. At approximately 1,140° it inverts to a different form, pseudo-wollastonite, which is known only in laboratory or technologic products. The inversion is rather sluggish, too, and it seems inevitable that pseudo-wollastonite would have survived in some rocks if it had ever formed. Or again, if some wollastonite is formed secondarily by inversion from pseudo-wollastonite, it should in at least some instances give evidence of that fact. No such evidence has been found. It is difficult to avoid the conclusion that in no rocks has the crystallization of $CaSiO_3$ taken place above 1,140°, nor yet has any rock, occurring as inclusions in a melt and containing wollastonite, been heated to a temperature as high as 1,140°. The substance $NaAlSiO_4$ furnishes another example of the same general relations. In the laboratory it is transformed at 1,248° to a modification which is quite unknown in nature.[5] The same reasoning applies to it as to the substance $CaSiO_3$. We are here concerned with a somewhat higher temperature, but there is confirmation of the conclusions reached on the basis of $CaSiO_3$. These and other substances with similar relations furnish indisputable evidence that the temperatures attained in geologic processes in the accessible part of the earth, were comparatively moderate, even in the highest-temperature stages of these processes.

On the other side of the picture, we have a number of substances which invariably give evidence of having cooled through an inversion point and therefore of having been formed above that inversion temperature. The evidence is ordinarily the presence of a complex twinning which is known to develop at certain inversion points. The majority of these inversions lie at comparatively low temperatures, and therefore, although the minerals concerned always form above the inversions, in no particular do they furnish evidence contradictory to the evidence cited above of the moderate temperatures of geologic processes. Among the substances in this class may be mentioned argentite (Ag_2S) with an inversion at 189°, boracite ($Mg_6B_{16}O_{30} . MgCl_2$) at 265°, cryolite ($Na_3AlF_6$) at 570°, leucite ($KAlSi_2O_6$) at 603°. The last of these is a rather high temperature, yet it appears that natural leucite has nearly always, if not always, formed above this temperature.[6]

[4] N. L. Bowen, J. F. Schairer and E. Posnjak, *Am. Jour. Sci.*, 26: 207, 1933.

[5] N. L. Bowen, *Am. Jour. Sci.*, 33: 560, 1912.

[6] Leucite, and indeed some of the other substances above listed as being in this class, may sometimes show twinning even when formed in the laboratory below the inversion temperature, but such twinning can usually be distinguished from that originating during inversion and has not been definitely recognized in the natural mineral.

Phase Equilibria in Polycomponent Systems

For the most part, only phase equilibria in systems of a single component have been discussed as "fixed" points. In each case they represent univariant equilibrium and, as already pointed out, are fixed only when the pressure is fixed or known. Any equilibrium may, theoretically at least, be equally useful, however great the number of phases involved, provided that the reaction is univariant, that is, that the number of phases exceeds the number of components by one. Some hint of the use of such equilibria has been given in the mention of melting temperatures of mineral assemblages. There are other kinds of equilibria among a number of phases that may be of service especially for the establishment of temperatures of mineral development in metamorphic rocks. Some of the reactions involve a gas phase and here the effect of pressure on any univariant equilibrium is so great that, unless there is field evidence which determines the approximate value of the pressure, the temperature of the reaction may be set only within rather wide limits. Even when the actual magnitude of the pressure is quite unknown, reactions of this type may have some temperature orienting value, especially where different reactions have taken place in different parts of a rock mass so disposed that all parts of it must have existed under substantially the same pressure.

The dissociation of carbonates with evolution of CO_2 is a reaction of the type under consideration. The dissociation pressure of calcite ($CaCO_3$) has been measured at temperatures up to those of melting, and in the light of this knowledge it is not surprising that examples of this reaction are not found in nature. To be sure, $CaCO_3$ dissociates freely with formation of CaO and CO_2 at a temperature of 900° when the pressure is only 1 atmosphere, but the weight of only forty meters of rock is sufficient to prevent dissociation at 1,100°. To such a temperature limestones have probably seldom been heated even at much greater depths.

Other carbonates such as magnesite ($MgCO_3$) and dolomite ($CaMgC_2O_6$) have higher dissociation pressures at corresponding temperatures, and their dissociation has occurred in nature. Magnesite is not a common mineral, but dolomite is common and geological evidence points to its dissociation when heated, with formation of periclase (MgO), calcite and CO_2 according to the equation

$$CaMgC_2O_6 \rightleftarrows MgO + CaCO_3 + CO_2.$$

From laboratory experiments something is known of the CO_2 pressures of this univariant reaction at various temperatures.[7] If there is field evidence revealing the depth of burial of a dolomite at a time when it was heated, say by contact with an igneous intrusive, it may be possible to reach some conclusion as to temperature, usually the fixing of a temperature above which it could not have been heated.[8]

Calcite itself reacts with certain other minerals, with evolution of CO_2, at temperatures far below those at which simple dissociation of calcite will occur. Thus calcite and quartz react according to the equation

$$CaCO_3 + SiO_2 \rightleftarrows CaSiO_3 + CO_2.$$

This is a univariant equilibrium and the pressure of CO_2 has thus a definite value for a given temperature. In some quartz-calcite rocks this reaction has failed to occur; in others it has occurred with formation of wollastonite ($CaSiO_3$). This difference of behavior is observed at times in adjacent parts of the same rock mass, from which facts it may be possible to reach conclusions as to the relative tem-

[7] W. Eitel, *N. Jahrb. f. Min., Beil. Bd.*, 51: 477, 1924.

[8] The experimental values indicate that even at a depth of 0.5 kilometer dolomite would be dissociated by heating to a temperature of about 600°.

peratures prevailing. The actual temperatures could be deduced only on the basis of experimental determination of the pressures of CO_2 for this reaction at various temperatures. No satisfactory results have been obtained. Calculations have been made of the values of the pressure at various temperatures, assuming the validity of the Nernst heat theorem.[9] These can give no more than a rough approximation of the truth, but until something better is available they are not without some value. The depth of burial being known, the failure of the attainment of a certain temperature is recorded in the rock by the failure of this reaction, that is, by the persistence, side by side, of calcite and quartz. The quartz-calcite association would be one of the more valuable temperature recorders if adequate knowledge were available of the *p, t* curve of this univariant reaction.

In addition to these reactions occurring in rock metamorphism and involving a gas phase, there are a great many reactions in which no gas phase is concerned. An example in which there are four reacting phases is furnished by the equilibrium between wollastonite and anorthite, on the one hand, and garnet and quartz, on the other, according to the equation

$$2CaSiO_3 + CaAl_2Si_2O_8 \rightleftarrows Ca_3Al_2Si_3O_{12} + SiO_2.$$

Since there are three components the reaction is univariant and has a definite *p, t* curve, but for it and most other reactions between a number of phases the information needed for the construction of such curves is lacking and knowledge regarding the temperature-pressure relations is available only in so far as field relations permit their placing relative to some of the reference points already discussed. Since many such reactions are, however, capable of furnishing independent fixed points, they no doubt will so function as experimental results are accumulated.

There is one unusual type of rock for which there is a great volume of experimental results applicable to the temperatures of formation of the constituents. This rock is that which occurs as beds of potassium salts, such as the Stassfurt salt deposits, the origin of which is still, in some of its details, an open question. Complex equilibria between a considerable number of phases are here concerned, and there are certain individual phases and again certain phase assemblages that have minimum temperatures of formation. These are useful temperature recorders. Among them we may mention only the individual phase vanthoffite, $MgNa_6\ (SO_4)_4$, with a minimum temperature of formation of 46° from the complex solutions, and the assemblage sylvite (KCl), kieserite ($MgSO_4 . H_2O$), halite (NaCl) with a minimum formation temperature of 72°. Since such temperatures can not be supposed to have existed during the evaporation of the natural brines, it must be concluded that the deposits have been subjected to these higher temperatures as a result of burial beneath a significant thickness of other strata, with consequent metamorphism (recrystallization) and formation of the higher temperature phases and phase assemblages.

The experimental investigation of the potash salt equilibria was carried out largely by Vant Hoff and his associates, and it is to him that we owe the expression "geologic thermometer."

Conclusions Regarding Temperatures of Geologic Processes

In their full details the conclusions reached as to temperatures of various geologic processes by the use of the various recorders are the concern of the geologist, but some general conclusions may be mentioned here.

[9] V. M. Goldschmidt, *Vidensk. Skr.* 1: (22), 1912.

The temperatures of magmas (molten rock) have seldom if ever exceeded 1,200° when they have arrived in that part of the crust of the earth which becomes accessible to observation as a result of erosion. Most magmas have probably not exceeded 900°, and some, especially those rich in alkali-aluminous silicates, have had temperatures little in excess of 600°. The temperatures of consolidation (crystallization) of the igneous rocks formed from these magmas are but little lower than the temperatures of the magmas themselves; in short, the magmas carry little super-heat. The temperatures of crystallization are highest for the rocks rich in lime-magnesian constituents and lowest for those rich in alkali-aluminous silicates and free silica. The temperatures of crystallization of pegmatites, which are formed from residual magmas especially rich in water and other volatile substances and are one of the storehouses of the radioactive elements, lie in the neighborhood of 573°. Mineral veins formed from the residual aqueous solutions after crystallization of the main rock constituents were deposited at temperatures, in part, approaching those of pegmatites and extending from this range down to the temperature of boiling water and even lower, with characteristic minerals at each stage.

So much for the rocks and mineral deposits formed in descending temperature stages of the geologic cycle. There are, in addition, rocks and mineral deposits formed under conditions attended by rising temperatures. Sediments and other materials formed at the surface of the earth and at the temperatures there prevalent may be buried under later accumulations and as a result of such burial they experience a rise of temperature. New minerals sometimes form, the original minerals invert to high-temperature forms and some assemblages probably suffer a certain amount of selective fusion. The extreme of reheating is experienced when such materials are immersed in molten magmas, in which case the more susceptible are themselves melted, but the indications are that even under these most extreme conditions rock materials have probably never been heated above 1,150°.

THE DETACHMENT OF SCIENTISTS?

The photochemical mechanism which produces plant life is one of the most basic of the processes that have made possible the complex evolution of life on this planet. We are a product of that evolution, and we have an underlying curiosity. It is not an idle curiosity, unless indeed the most stirring philosophies that have moved the mind of man are all idle. Far from being futile, it is the attribute which gives man such true dignity as he succeeds in preserving in the midst of the buffeting of his hazardous existence. To unravel one of the great mysteries of life is an ambition which needs no apologies, and it is this ambition which spurs us on to try to understand the primary plant process. We need no stronger justification for our conviction of the enduring value of what we do.

Our detachment makes it possible for us to keep the even tenor of our way and largely to devote our efforts to inquiries which are the most fascinating that engage the scientific mind, and which will require long and continuous effort by many men for their solution. Some of us certainly should depart at least temporarily from this sustained effort if we see a way in which our science may definitely aid in mitigating some great immediate ill that threatens humanity. Most of us can continue along the familiar path, with clear consciences, toward a distant goal. We should be humbly grateful for the opportunity that is ours, we should be full of sympathy with those who do not share our blessings, and we should be assiduous in the preservation of the spirit of true science in a time of exceeding stress.—*Report of the President of the Carnegie Institution of Washington, 1939.*

SOLUTION GARDENING

A NEW APPLICATION OF SCIENCE TO AN ANCIENT ART[1]

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THE scientific study of the mineral nutrition of plants has engaged students of plant physiology for about eighty years. Carried forward rapidly by means of refined laboratory experimentation, that study has resulted in an ever increasing fund of knowledge, much of which has become practically applied. That the nutritionally essential part of the soil is just its liquid phase—which is the soil solution—was soon established, and many kinds of plants were satisfactorily grown in experimental cultures without soil, with their roots in small jars of artificially prepared nutrient solutions. In some cases these solutions, made up from distilled water and highly purified mineral salts, were found to support as good growth as was had when highly productive soils were used, but that observation was beside the main point and it failed to attract the attention of gardeners or farmers. Nitrates, phosphates and sulphates of potassium, calcium, magnesium, ammonium and iron were employed in various proportions and partial concentrations, and a large number of excellent nutrient solutions was developed by numerous experimenters, for their laboratory studies. In the latter part of the eighty-year period boron, manganese, copper and zinc have been found to be generally essential for plant health, but they are required in exceedingly low concentrations. Some free oxygen is generally needed in the root environment and much attention has been devoted to soil aeration and to the aeration of experimental nutrient solutions. When acidity of solutions came to be seriously studied, it promptly emerged that this solution characteristic was markedly influential on plant health; it is generally necessary that a good nutrient solution be somewhat on the acid side of neutrality and plants frequently lower the acidity of the solution around their roots as they grow. To avoid uncertainties contingent upon alteration of the solution in the intervals between renewals, the special and very satisfactory technique of continuous flow was developed, whereby fresh solution enters the culture jar continuously, an overflow being arranged to care for the waste. Altogether, the experimental technique of controlled solution culture for the scientific study of nutrition is one of the most nearly perfect of all scientific procedures thus far developed; with suitable modifications it is now employed in many fields of research besides plant physiology.

With increase in knowledge about the mineral nutrition of plants the new findings and generalizations were promptly applied practically in agriculture and horticulture, and some of the most important advances in physiology were made by laboratory experimenters whose main interests were practical. Modern fertilizer practice was rapidly developed. Such salts as had been used in the laboratory were applied to the soil of garden and field with excellent results. Practically minded students developed their own experimental procedures for testing and improving the productivity of soils through experimentation with special

[1] An excellent account of the history of solution culture will be given by Dr. John W. Shive in an early number of THE SCIENTIFIC MONTHLY.

soil cultures, sometimes in pots but often by means of fertilizer-treated plats in garden or field. Analytical chemical techniques were developed for comparing the soil solutions of different soils, and a new science of soil chemistry came into being. Its numerous devotees were naturally not greatly interested in the theories of plant nutrition excepting as they might furnish guides to the large-scale growing of crop plants in soil. Experimentation with solution cultures was consequently left largely to those whose interests were mainly theoretical.

It was not very difficult to find out, by plat and pot experiments, what fertilizer applications had been beneficial on specific kinds or areas of agricultural soils—for the proof of a pudding lies in the eating—but to understand just why one fertilizer treatment proved to be more advantageous than another or why any specified treatment gave different results with different soils and crops, constituted a very difficult problem. Since most soils are very complex and variable and because they fluctuate so widely and rapidly in water content and in other respects, they do not lend themselves readily to artificial control and scientific study. Despite great advances made in the art of plant growing by means of soils, the relations between plants and the soils in which they are rooted still constitute a topic whose serious consideration involves numerous uncertainties and conflicting opinions, many blunted conclusions and vague hypotheses. On the other hand, although the laboratory practice of solution culture, highly developed as a subsidiary art for physiological study, still presents many uncertainties of its own, the relations between the plants of such cultures and their root environments are already relatively well understood.

An interesting modification of solution culture was introduced early in laboratory experimentation, a modification by which some of the less troublesome features of ordinary soil culture might be brought under surveillance without introducing many of the more troublesome features. Sand culture was thus brought forward, and it has been highly developed in the laboratory, along with true solution culture. Purified sand, or fine gravel, impregnated (but usually not saturated) with artificially prepared nutrient solutions and held in suitable containers, is employed as culture medium. Excellent mechanical support for the plants is thus provided. The roots ramify throughout the container and, since the solution is distributed in the sand or gravel without completely filling the interstices, this method facilitates root aeration through gas exchange with the air above. Used solution may be washed out and replaced at intervals or fresh solution may be added, either continuously or intermittently, with or without occasional temporary flooding; free bottom drainage is of course provided.

Although the techniques of solution culture and sand culture were devised and developed to a high degree of perfection, for the scientific study of plant nutrition rather than for the practical growing of plants, and although the increasing knowledge secured through their use in fundamental experimentation was promptly applied to practical soil culture in many ways, it is only in the last decade that these special procedures themselves have begun to be applied in gardening. Their introduction in that field is now well advanced. It constitutes the most fundamental improvement in garden practice to be proposed since specific chemical fertilizers began to be used on soils.

The refined laboratory methods have been so simplified and otherwise modified that their use constitutes two really new types of gardening, which are superficially different but essentially alike in

principle. Soils, and the complexity of uncertainties that arise from their use, are dispensed with altogether. Rectangular basins of concrete, sheet iron or wood, eight or ten inches deep and suitably coated with asphalt or asphalt emulsion, are employed instead of garden beds. For applied sand-culture technique the basins are nearly filled with clean sand, cinders or gravel, to which suitable artificial nutrient solutions are added, to be renewed at intervals or continuously. For applied solution-culture technique artificial nutrient solutions are used alone in the basins, without sand or other soil-like material. The plants are rooted in the wet sand or cinders, by which they are supported as though in soil, or else they are held at crown or stem base in a mat of excelsior, straw or the like, the mat being in turn supported by a simple asphalt-coated frame of wood and wire that rests on the basin rim while the roots extend downward into the solution below. The supply of both water and mineral nutrients is readily maintained by either method, according to any suitable solution formula and renewal plan, and the acidity of the solution is easily corrected from time to time as it becomes altered. Arrangements for adequate oxygen supply to the plant roots are easily provided. Since no soil is used, there is no spading or cultivation, nor is any weeding necessary, excepting perhaps in rare instances. Water and the fertilizer salts used are not lost through downward movement and leaching, which are of common occurrence when soil is used. Tap water—or sometimes rain water—and inexpensive commercial salts are used in preparing the solutions. Artificial temperature control may be applied to the basins when desirable, by means of simple arrangements. Finally, those insects, other animal pests, bacteria and fungi that attack cultivated plants from the soil are practically excluded. It is clear that these new techniques allow the gardener to control root environments with a much closer approach toward precision than can ever be possible in classic gardening.

For example, one of the many nutrient solutions that have proved satisfactory in solution gardening may be prepared as follows. Mix very thoroughly in a glazed crock or wooden box: potassium nitrate (KNO_3, saltpeter), 2,000 grams (70.5 oz.); calcium nitrate ($Ca(NO_3)_2 \cdot 4H_2O$), 300 grams (10.5 oz.); mono-calcium phosphate ($Ca(H_2PO_4)_2 \cdot H_2O$, or the fertilizer called treble superphosphate), 500 grams (17.5 oz.); magnesium sulphate ($MgSO_4 \cdot 7H_2O$), 500 grams; ferrous sulphate ($FeSO_4 \cdot 7H_2O$), 50 grams (1.8 oz.); cupric sulphate ($CuSO_4 \cdot 5H_2O$) and zinc sulphate ($ZnSO_4 \cdot 7H_2O$), each 2 grams (0.07 oz.); borax, $Na_2B_4O_7 \cdot 10H_2O$) and manganous sulphate ($MnSO_4$), each 4 grams (0.15 oz.). Use this mixture at the rate of about 4 grams (15 oz.) per quart of ordinary water and add dilute solution of sulphuric acid (H_2SO_4, 1 volume to 9 volumes of water) by small increments and with thorough mixing, until the acidity of the resulting nutrient solution gives an *orange* color with the dye chlorphenol red, or a *greenish-blue* color with the dye bromcresol green; strips of dyed paper may be used for such acidity tests. Acidity should be tested, and corrected, at short intervals throughout the growth period and the whole solution should be renewed at intervals of a month or less. Very many different prescriptions for nutrient solutions have been recommended on the basis of results secured in practical tests and many ways by which the plants may be mechanically supported and supplied with solution have been described.

The methods of soilless gardening are specially suitable for the culture of small plants of rapid growth, either in the open or in greenhouses, and for relatively small gardens rather than broad fields. They have already been successfully ap-

plied commercially in vegetable gardening and floriculture. Perhaps their greatest promise lies in their applicability to greenhouse culture and to small home gardens. The familiar and classic labor of preparing garden beds with spade and rake, of weeding, hoeing and all soil cultivation, are to be replaced by less laborious, more effective and much more interesting procedures, and the familiar uncertainties of watering as well as of fertilizing are readily avoided. Suitable basins may be used indefinitely and their relatively small cost may be distributed throughout many years. The seasonal cost of the fertilizer salts used is remarkably small. The operations of preparing and renewing solutions and those of testing and correcting solution acidity when necessary are relatively easy and intrinsically interesting. In many instances, the crops produced have been judged to be of better quality than are commonly secured in more or less comparable cases of classic gardening, and many crops are also much superior in quantity per areal unit of garden space. The upper limit of productivity for these new-type gardens seems to be set, for any kind of plant, by temperature and sunlight, by the occurrence of destructive storms and, as in soil culture, by the gardener's ability to combat the inroads of insects and other animals, fungi and bacteria, which may attack the aerial portions of the plants.

To guard against excessive optimism, it should be emphasized that soilless gardening is still in a very early experimental stage; consequently occasional failures or partial failures are naturally to be expected. Advance in the new field of application must still depend on practical gardening experience rather than on thorough knowledge of the esoteric and intricate details of plant nutrition. For small home gardens, whose owners like to experiment with different kinds of plants and different treatments or who like to lead in new interests, these methods are specially attractive.

When the use of artificial nutrient solutions instead of soils for practical plant culture was first proposed it received but little favorable comment either from plant physiologists or from scientific horticulturists, although those people may be supposed to have been well informed about the use of solution culture in scientific experimentation. But the novelty of the new gardening methods and the remarkably excellent results secured by their means quickly aroused great popular interest throughout this country and abroad, for many people are interested in gardens and in new ways of doing things. Popular articles promptly appeared in American newspapers and magazines, many of which were so highly imaginative and contained so many greatly exaggerated or untrue statements that the new gardening appeared miraculous to many who were unfamiliar with what had been going on in scientific laboratories for six decades. Although they certainly represent nothing new in the field of science, these methods are really new in the applied field of plant growing.

The practical use of artificial solutions without sand or other soil substitute, for vegetables, crop plants and ornamentals, was begun little more than ten years ago by Dr. William F. Gericke, of the University of California. It was he who introduced the newly-coined word *hydroponics* (water culture), to distinguish what may now be called "Gericke gardening" from classic soil gardening on the one hand and from applied sand culture on the other. The term aquaculture had been applied to the growing of animals and plants in natural waters with soil bottoms, such as ponds and streams. Others have employed the expressions *chemiculture* and *soilless* gardening to mean simply gardening by means of artificially prepared nutrient solutions,

either with or without sand or similar solid material.

The commercial use of artificial solutions with sand, gravel or cinders in greenhouses has been developed parallel with Gericke gardening. That development began with sand-culture tests by Dr. John W. Shive and his associates at the New Jersey Agricultural Experiment Station.

Whatever terminology may eventually come into general use for these new types of gardening and whatever practical results may be achieved through the new methods, the theory and technique of growing plants with an artificially controlled and fairly well understood supply of mineral nutrients has now begun to spread outward from scientific laboratory to ordinary garden, window garden and greenhouse. Thus an additional chapter of scientific knowledge and of the application of the scientific method of thought is attracting many thousands of intelligent people who might otherwise hardly be aware of the existence of the science of plant physiology. This popular movement is perhaps socially just as important in that less tangible way as it is from the more obvious and prosaic standpoint of vegetable and flower production. Some knowledge about the mineral nutrition of garden plants and their relations to their surroundings, together with homely familiarity with some of the methods of experiment and thought by which such knowledge has been and is being built up, should lead toward broader and better appreciation of the nature of plant life among people whose main interests lie elsewhere.

At least eight recent popular books on the new gardening present the subject in many different ways. All are good. These books are briefly characterized in the following paragraphs.

(1) One of the earliest, if not the very earliest, of the books devoted to practical soilless gardening was the first edition of Dawson and Dorn's little volume,[2] which is now in its third edition, to which reference is here made. The story is told clearly and interestingly, for readers who are largely unfamiliar with biological and chemical knowledge, and it is exceptionally reliable and complete for such readers; it is also brief, but it is accompanied by many helpful references of various kinds. It gives answers to most of the simple questions that might be asked by a naive beginner and it contains also many original observations based on experience. Familiar, as they say, with the common man's "hunger for information on wholesome subjects," the authors express the hope that "the process of certain chemicalization of [human] food values by means of deliberate fertilization" (artificial control of plant nutrition) will aid toward "mankind's well-being without the heavy toil of cultivating the earth."

(2) Ellis and Swaney[3] are also pioneers in this field of popular writing. Their book is now in its third printing. An elementary account of some features of plant physiology constitutes the first chapter and a subsequent chapter presents some information about organic growth-promoting substances. Solution, sand and cinder culture are clearly described, with many illustrations, some of them colored. Special attention is devoted to window gardening and the culture of plants in the home. A number of formulas for nutrient solutions are

[2] C. D. Dawson and M. V. Dorn. "Plant Chemiculture, a Guide to Experiments in Growing Plants without Soil." 3rd revised ed., illustrated, about 130 pages. Publ. by the authors, Los Angeles, 1939.

[3] Ellis, Carlton and Miller W. Swaney. "Soilless Growth of Plants: Use of Nutrient Solutions, Water, Sand, Cinder, etc." Illustrated, about 150 pages. Reinhold Publishing Corporation, New York, 1938.

given. The authors offer to supply a trade-named mixture of salts ready for use by amateurs; indeed the book bears a coupon entitling the purchaser to a free sample of the mixture.

(3) A volume by Connors and Tiedjens,[4] which comes from Rutgers University and the New Jersey Agricultural Experiment Station, is at once readable, practical, scientific and reliable. It presents not only many of the main elementary considerations concerning plant nutrition and plant culture with and without soil, but also much information and discussion such as are generally found only in technical publications. The book is well illustrated with drawings and photographs, some of the latter colored.

(4) Commercial growers as well as amateurs should gain much from Turner and Henry's book,[5] which is generally both scientific and practical as well as scholarly. Main attention is given to greenhouse culture by means of gravel or cinders. Many solution formulas and extensive instructions are given, with useful illustrations showing methods and results. Several colored plates add to the general attractiveness of the volume. The authors' observations on the suiting of solution composition to light conditions and to seasons of the year are of special interest; for example, a good solution for rose culture in December at Urbana was found to be unsatisfactory in June. These authors offer to supply reagents used in testing solutions for the main nutritive elements.

(5) A book by D. R. Matlin,[6] constitutes an elementary primer, introducing artificial solution culture at the high-school level. It gives simple accounts of elementary chemistry and plant physiology, includes a number of attractive illustrations and brief but clear directions for installation and care of cultures. A number of solution formulas are presented, with adequate detail. The account is largely a report on the author's own experience or on that of his young students at a Los Angeles high school. This is a handy and interesting little book for beginners; it should arouse interest and encourage experimentation and thought.

(6) An excellent book on the new gardening is by Dr. William F. Gericke,[7] whose pioneer experiments on the practical application of solution culture aroused the present wide-spread interest in these new gardening methods. Before turning to this application, its author had been engaged for many years in physiological studies on the mineral nutrition of plants, and this account—which is his first comprehensive publication on solution gardening—is replete with both practical and scientific observations of many kinds. Directions are given for the preparation of basins, supporting mats and nutrient solutions, for solution testing and renewal, and for the general care of cultures. The story of the author's early trials and of the subsequent development of his improved techniques is of special interest. Tests

[4] Connors, Charles H. and Victor A. Tiedjens. "Chemical Gardening for the Amateur: Gardening without Soil Made Easy." Illustrated, about 250 pages. Wm. H. Wise and Company, New York, 1939.

[5] Turner, Wayne I. and Victor M. Henry. "Growing Plants in Nutrient Solutions, or Scientifically Controlled Growth." Illustrated, about 150 pages. John Wiley and Sons, New York, 1939.

[6] Matlin, D. R. "Growing Plants without Soil: The A-B-C of Plant Chemiculture (Soilless Agriculture, Chemiculture, Water Culture, Hydroponics, Tank Farming, Sand Culture), Including Plant Growth Hormones and Their Use." 2nd revised ed., illustrated, about 50 pages. Chemical Publishing Company, Inc., New York, 1940.

[7] Gericke, William F. "The Complete Guide to Soilless Gardening." Illustrated, about 280 pages. Prentice Hall, Inc., New York, 1940.

with a very large number of plant forms are reported, mostly in outdoor culture at Berkeley, California; a partial list of the forms tested includes: tomato, cucumber, watermelon, squash, potato, sweet potato, maize, parsnip, carrot, beet, turnip, radish, onion, lettuce, cabbage, parsley, celery, strawberry, marigold, narcissus, tulip, gladiolus, dahlia, fuchsia, gardenia, rose. Several forms were sometimes grown one after the other in the same basin, to produce a succession of crops in a single season. The book is written in attractive, readable style, sufficiently simple for intelligent beginners but generally precise enough for those who already know their plants.

(7) Somewhat more than half of Alex Laurie's excellent book[8] is devoted to the elementary principles of soil culture and it should be very valuable to any gardener. Sand culture, gravel culture and hydroponics are clearly described, mainly for greenhouse production, and a final chapter is devoted to some special culture methods for amateurs. This is a readable and reliable presentation. The author, who is professor of floriculture in Ohio State University, is a scientific horticulturist, interested in aiding commercial growers as well as amateurs. The book is well illustrated.

(8) "Gardening without Soil," by A. H. Phillips,[9] is a delightful presentation of this subject from a British view-point. Exceptionally well written and satisfactory, it seems to be sufficiently complete, although it may hardly be taken to "offer all the information at present obtainable on the subject" or to be "as practical a guide to this new science as it is possible to collate," as the introduction not too modestly says. A detailed account of some actual cultures carried out in England in 1938 is added as a short appendix. The usual brief account of the main elementary principles of plant nutrition is followed by clear and concise directions for installing basins and plants and for their care. The techniques described are based on those of Gericke, with some modifications. Correct emphasis is placed on the importance of root temperature; for many plants, best results are to be expected when the solution temperature is kept between 70° and 75° Fahrenheit. A number of diagrams and photographs are included, which illustrate and add to the general attractiveness of the volume.

[8] Laurie, Alex. "Soil Culture Simplified." Illustrated, about 200 pages. McGraw-Hill Book Company, New York, 1940.

[9] Phillips, A. H. "Gardening without Soil." Illustrated, about 140 pages. Chemical Publishing Company, Inc., New York, 1940.

"THE TRUE MISSION OF THE RACE"

There is still a duty to keep the torch of pure science lit, and this duty is only the greater under stress. All the long struggle of a harsh evolution, the pitting of species against the environment, has produced a being whose primary distinction is conscious cerebration, and whose crowning attribute is his intellectual curiosity concerning his complex environment and a thirst for knowledge transcending the mere struggle for existence. If there is no abiding value in a Beethoven symphony, or a theory of the cosmos, or the tracing of an ancient culture, then the Carnegie Institution of Washington has scant reason for existence. If it is really good that man should look at the stars and should contemplate his great destiny, then it is imperative that in those regions which enjoy the blessings of peace the search for the eternal verities should continue.

The dual character of science influences much of our outlook. We look at the stars, and we build yet greater machines to aid our vision, for two reasons. The stars are a laboratory, wherein are pressures and temperatures far beyond those we can artificially produce; which we can merely observe and not manipulate. Nevertheless, through thus observing we have already learned many things which have advanced the science of physics and in turn its applications. All this is to be welcomed, yet it should not completely dominate our thought. We also look at the stars for the same reason that inspired the shepherd on the ancient hill, because we are bound to think of greater things than the comforts or dangers of the morrow, perhaps because thus to inquire and to speculate is the true mission of the race.—*Report of the President of the Carnegie Institution of Washington, 1939.*

A SERPENT-SEEKING SAFARI IN EQUATORIA

PART II
CONGO AND TANGANYIKA TERRITORY

By ARTHUR LOVERIDGE

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THE steamship *General Tombeur,* on which we sailed down the lake, was a comfortable little craft, and we greatly enjoyed the lovely scenery—rocky scarps and verdure-clothed islands set in a placid lake beneath an azure sky. Later in the day black clouds gathered and we were subjected to heavy rainstorms. It was after sunset before we reached Mamvu on Idjwi Island, and we should not have done so at all but for the exceeding kindness of Mons. v.d. Berck v. Heemstede, who came off in his launch and took us, together with our camping equipment, ashore in the beautiful bay in which he has made his home. Nor was this all, for the family placed the tennis lawn at our disposal for the pitching of tents and entertained us most hospitably. To sit in their comfortable lounge and listen to music from Brussels and Berlin or a B.B.C. broadcast was an unforgettable experience. The island in a Central Africa lake had seemed so remote and cut off from the world, yet here was the day's news brought to us from troubled Europe!

As soon as porters could be provided we set off for the mountain which dominates the island, and pitched our tents at Mulinga. From this altitude I made daily excursions into the forests that cap the surrounding heights. The race of blue monkeys peculiar to this island, named *schoutedeni* after the director of the Musée du Congo Belge, was becoming rare, and two were shot only with considerable difficulty, for the animals were much harassed and hunted by the Batwa pigmies, whose shouts and cries when in pursuit we heard on several occasions. I also came on the primitive shelters which these little people make in the bush, and once, when caught in a terrific thunderstorm far from camp, witnessed the celerity with which my pigmy guide could construct such a refuge. This man, son of a chief, though of very short stature scarcely seemed to me to be a full-blooded Batwa. He first came to my camp with a dwarf species of lemur and, appropriately enough, followed this up with a pigmy chameleon! After paying for them I made him a present of several razor blades. They proved irresistible, for he ruined his good looks by shaving his head bald, after which he looked ugly indeed.

Ujiji, famous as the meeting place of Livingstone and Stanley, is only five miles from Kigoma, and we drove out there to pitch our tents beneath the mighty mango trees under which I had camped in 1930. Then I was in search of a limbless lizard known only from two examples in the Berlin Museum. Once again I failed to find it, but fortunately the natives were more successful, bringing in five towards the end of our brief visit. Better still, while hunting for the elusive burrowing creature I discovered a new species of skink of which we got a good series. Another interesting find was the first Tanganyika record of a so-called "two-headed snake" (*Chilorhinophis*). The stumpy tail of this handsomely colored and exceedingly elongated serpent is marked precisely like the head, even to eye-spots. As the reptile wriggles along, its head is applied to the ground, but

the tail is upraised clear of the ground and poised as if about to strike. Thus one receives the impression that the snake is wriggling backwards, alert and ready to fight a rearguard action rather than suffer any interference!

Not content with having asked the District Officer at Kigoma to instruct the Liwale of Ujiji to announce to his people at a dance that I was anxious to buy limbless lizards and snakes, I lost no opportunity of drumming it in by stopping almost every native I met. For example, a lad with ragged shirt would be sitting idly outside his hut. Halting abruptly, I would ask if he wanted a new shirt and get an eager affirmative. "Then why sit idly there when you can get thirty cents (8¢ U. S.) for every limbless lizard or snake which you bring me. You've only to get fifteen and you'll be able to buy a new shirt yourself. Remember, it's only this week that I'll be here." A little later I was superintending the turning over of a likely mountain of rubbish surrounding a mango tree in a native plot: two natives from the adjacent *shamba* (garden) strolled over to watch and inquire what we were doing. "Looking for snakes with two mouths," I replied in the vernacular, following this up with the usual patter. Just at that moment my boys uncovered one (*Typhlops graueri*); I seized and transferred it to a lethal bottle. "That's thirty cents lost to you," I commented to the onlookers. A second followed the first. "You might have had sixty cents if you'd only had the energy to turn this over." Came a third, all within ten minutes. I did recall such good fortune before, but keeping a straight face I continued airily: "Ninety cents just thrown away." Their eyes were round with astonishment and they

HOME SWEET HOME IN THE HEART OF AFRICA

ONE OF THE HOMES PASSED BY THE EXPEDITION. CONTENTMENT ABIDES WITH FEW POSSESSIONS.

A SEMI-PIGMY OF THE BATWA TRIBE

THIS MAN, CLOTHED IN A CIVET SKIN, WAS ONE OF HUNDREDS WHO VISITED OUR CAMP AT BUNDIBUGYO IN WESTERN UGANDA.

conferred together rapidly. "We will hunt for them to-morrow," said one. "To-morrow, to-morrow," I gibed. "Always, to-morrow; and to-morrow the sun will be hot and you will say 'To-morrow.' And the day after the day after that I shall be gone, and then where will you find a European who is fool enough to pay 30¢ for a snake?" "We will go now," they chorused, and set off to find a hoe. We continued digging for an hour but failed to find another snake, neither did they!

For two of us the safari was drawing to a close. My wife was busy packing the last of nearly two thousand plants which she had collected for the Gray Herbarium; with Brian's departure I was to lose my photographer-in-chief, who had taken all the photographs which illustrate this account. Mournfully we entrained for the forty-six-hour journey to Dar es Salaam on the coast.

Our train was running late, so it was a tired trio that reached the New Africa Hotel at 8 P.M. on Saturday night. On arrival we learned for the first time that the little coastal steamer *Tayari* was scheduled to sail for Mikindani at 6 P.M. the following Monday. However, sailings for Mikindani were too few and infrequent to be passed over lightly, so I decided to catch the *Tayari*, leaving my wife and son to sail for Europe the following day.

It was at Mikindani that the Yao tribe revolted in 1888 and drove out the Germans. Twenty-two years earlier Livingstone had landed here and taken the old trail across the hills to the Ruvuma River on his way to Lake Nyasa. His companion, Kirk, later Sir John Kirk, Her Majesty's consul at Zanzibar, accompanying him at the outset, had collected three little sedge-frogs in Ruvuma Bay. These had subsequently been described as new

A BANYARUANDA RAINCOAT

IN THE MOUNTAINOUS, WIND-SWEPT COUNTRY OF SOUTHWESTERN UGANDA, PASTORAL PEOPLE HAVE DEVISED A LIGHT AND SERVICEABLE SHELTER OF BAMBOO AND BANANA LEAVES TO PROTECT THEM FROM WIND AND RAIN.

by Dr. Günther. The status of two of them was somewhat obscure but might be elucidated if fresh topotypic material were secured—hence my journey—over the hills I went—but by lorry.

Camp was made on the banks of the Ruvuma commanding a fine view of the spot where the German forces under von Lettow Vorbeck retreated into Mozambique on the night of November 25–26, 1917, leaving German East Africa in the hands of the British. A lion, we learned, had taken a man from his hut four days before our arrival, and within a couple of miles of our camp. As we drove along I had noted the stout stockaded chicken houses, mostly on stilts.

As sedge-frogs usually remain under water by day, only ascending the sedges at night, it was necessary to hunt them after dark by wading in the swamps with flashlights. While I was protected by hip-high wading boots the legs of my two native assistants were bare. The very first night we were successful in getting one of the species, which subsequently proved to be very common in the region. The third night we shifted to another extensive swamp separated from the crocodile-infested Ruvuma by a hundred feet or so of low bank. We had been hunting for half an hour when one of the boys cried "Quick, sir! A turtle!" I hastened as best I could to where he was, but by the time I got there the turtle had decamped. These turtles were "flapjacks" of considerable size; the largest of eight which we collected weighed twenty-five pounds. "Of course," added Kizamba, "this water is plenty deep enough for crocodiles too." The next night there was a yell from Ali, who got a horrid fright from treading on a turtle in deep water.

Previously no thought of crocodiles had crossed my mind. Now that Ki-

A MNYARUANDA DANDY AT NYAKABANDE

THIS YOUTH PROBABLY OF THE HORORO SECTION OF THE TRIBE, EXHIBITS ONE OF THE NUMEROUS TYPES OF COIFFURE FASHIONABLE AMONG THESE PEOPLE. A RAZOR BLADE WAS THE PRICE HE CHARGED FOR PERMITTING HIS PORTRAIT TO BE TAKEN.

A MNYARUANDA WITH CROWNED CRANE

THE BIRD DEPICTED IS ONLY A NESTLING, AND AS SUCH FALLS EASY PREY TO THE NATIVES, FOR THE NESTS OF THE CRANES ARE ONLY A MASS OF SEDGES IN SWAMPS OR ALONG EDGES OF LAKES.

BUYING ETHNOLOGICAL MATERIAL ON CHRISTMAS EVE
IN THE BWAMBA COUNTRY OVERLOOKING THE SEMLIKI VALLEY WE LEFT ZOOLOGICAL PURSUITS TO OBTAIN MATERIAL FOR HARVARD'S PEABODY MUSEUM.

zamba had mentioned it we all knew that in the middle, where the water was probably up to our necks, it *was* deep enough for the creatures. Next day as I was returning from an excursion with a local native acting as gunbearer, we had to skirt this swamp when the "boy" remarked quite casually: "I once saw three crocodiles basking together at this very spot." Asked when this was, he thought for some moments, then replied: "The day before your lorry arrived here. I remember because I was gathering firewood for an Indian at the time." "They were only four or five feet long," he added in response to a further question. Undeterred by this information, we returned again and got examples of the second species.

On the seventh day of our stay it poured the whole time and much of the night as well. Next morning we heard a noisy crowd of men and boys coming down the road. As they drew nearer it was seen they carried something on a stretcher. It turned out to be a stocky female crocodile measuring eight feet from snout to base of tail, but only three feet of truncated tail—the remaining five or so had been lost long since, for the stump was well-healed. It had wandered from river or swamp during the heavy downpour of the previous night and had been found resting in a field of maize.

Torrential rain fell during our stay, so that when the time came for us to move up the coast we had to proceed by native dhow from Mikindani, for no other craft would be available for several weeks. I arranged with a dhow master and confirmed the arrangement late on Saturday night that his dhow should be at the

wharf at 7 A.M. on the following Monday. We reached the wharf at 7:15, but alas, there was no dhow! The owner lived a mile round the bay; when he had been located he sent word that his craft was unseaworthy, so he could not take us! We could go by another dhow, which was leaving for Lindi at 11 A.M., he added. Instead of having the sole use of a dhow and getting away in the cool of the morning, we had to pile in on top of a lot of cargo, and it was near noon when we beat out of Mikindani Bay.

Midafternoon found us becalmed and for two hours we lay idly rolling in almost sweltering heat, despite black clouds over the land which from time to time deluged the coast with rain. It was shortly after sunset when we entered Lindi Bay, and then ensued three hours of almost fruitless tacking until the Arab captain, acting on my suggestion, cast anchor—a rock secured by rope—at 9 P.M. My camp bed was erected on the tiny afterdeck and I passed a refreshing night beneath the stars, sleeping without a mosquito net for the first time in six months, and waking at midnight to the luxury of a shiver! At 5 A.M. I was turned out, as the deck was required by the crew who had to haul on the sails. We reached land at 7 A.M., and ten minutes later I jumped ashore exactly opposite the Beach Hotel, where a bath and breakfast awaited me.

Our next destination was Mbanja, where Herr Ewerbeck, a former German administrative officer of Lindi, had collected yet another species of limbless lizard (*Chirindia*), examples of which we hoped to procure. Apart from other considerations it seemed advisable to secure a large series so as to be able to study the range of variation within a species of these degenerate, worm-like creatures, which are so rare in collections. When

A BIRD SKINNER AND HIS APPRECIATIVE AUDIENCE

WHEREVER WE WENT OUR SKINNERS WERE ASSURED OF AN AUDIENCE OF THE NEIGHBORHOOD'S SMALL BOYS. THE PROBLEM WAS TO SNAP THEM BEFORE THEY TURNED TO FACE THE CAMERA.

AN ARBOREAL FROG OF THE GENUS RANA

RELATIVE OF THE GREEN AND LEOPARD FROGS OF THE UNITED STATES, THIS SPECIES HAS DEVELOPED DISKS AND DWELLS IN THE TREES OR BANANA PLANTS.

SENEGAL FROG

THE RINGING NOTE OF THIS SPECIES SOUNDS LIKE A BURSTING BUBBLE OF WATER. WHEN MANY FROGS ARE ASSEMBLED, AS AT THE BREAKING OF THE RAINS, THEY CAN BE HEARD A MILE AWAY.

our lorry drew up at Mbanja village, however, I said "Drive on," for the village was situated on sunbaked clay and coral limestone among crocodile-infested lagoons and tidal estuaries. An amphisbaenid would, I knew, scorn such an environment, demanding a sandy or laterite soil for its habitat. When I explained this to my native driver, he nodded. "I know just the place," said he, and drove me up to the landing-field or aerodrome. Judge of my surprise on arriving there to find this magnificent stretch of flat country ditched or trenched in every direction. Later, I learned that at the time of Italy's seizure of Albania, there were good reasons for rendering the landing-field uncongenial to troop-carriers—hence the trenches. Now for the sequel—how Italy's annexation furthered my plans and benefited Harvard's Museum!

A gang of eight natives was about to fill in the trenches. I explained to them carefully just what I wanted, offering the usual 30 cents (8¢ U. S.) each for fifty undamaged examples of this creature. A look of chagrin flitted across the face of one of the men, and he made some comment in the vernacular to the foreman. "What was that he said?" I asked. "He says that he flicked one of them out of the way when he ran ahead of your lorry to show the way." This sounded promising; moreover, during the clearing of our camp site the men captured two little jet black worm-snakes—like the lead of a pencil come to life. This had given me the opportunity to demonstrate factually the offer of 30 cents. To make a long story short, my boys and I secured ten of the pink worm-like lizards, while sixty others were brought in by natives, chiefly the aerodrome gang engaged in filling in the trenches. They marveled at the ways of a white man wanting such worthless 'worms.' Just nine months before I had had to send to Hamburg to

borrow the damaged and only known example of the species!

As I was sitting down to tea in the entrance of my tent, an eagle settled in a tree a quarter of a mile away across the landing-field. Abandoning tea for the moment, I crossed to where it was and as I returned with the bird a number of local natives crowded round. "Good, good work," they chirped, "eater of chickens." "On the contrary," said I, "this big bird is a friend of yours, for it never eats chickens, and when Ali has skinned it you will probably find snakes in its stomach." As I drained my last cup of tea there were roars of laughter from the skinner's quarters. I walked over to see what was the cause. Ali, sitting in the shade of the mango trees, had just produced a three-foot stripe-bellied sand-snake from the eagle's crop. "Go ahead," said I, "open its stomach." When this was done two more snakes, of the same species but slightly smaller, were disclosed!

Though officially the rainy season, we had enjoyed *almost* a week of fine weather while at Mbanja, so it was just misfortune that during our last night a gale arose followed by torrential rain. I awoke at 1:45 A.M. as a tent pole snapped and got up to render first-aid. It was the end of sleep for me. Breakfast was over by 6 A.M., but the lorry which was coming for us got bogged and we did not get away until 8 A.M. It was what you might call "a day" in Africa or anywhere else, for my next meal, except for four pigmy bananas, was at 9:10 P.M. with clouds of mosquitoes from nearby Lake Rutamba humming and biting. To reach the lake we had had a march of three and a half hours, most of it in the dark, for the lorry had balked at a crazy bridge, honeycombed and undermined by termites.

While on this march we halted near a native hut whose owner hospitably

DWARF GALAGO FROM IDJWI ISLAND
APPROPRIATELY ENOUGH, THIS DWARF LEMUR WAS BROUGHT IN BY A HUMAN DWARF, REMNANT OF THE FOREST PIGMY RESIDENTS.

A PIGMY CHAMELEON
ONCE MORE, IT WAS A PIGMY TO WHOM WE WERE INDEBTED FOR THIS PRIZE. MEMBERS OF THIS GENUS LACK THE PREHENSILE TAIL OF THE LARGER SPECIES AND THEIR COLOR REPERTOIRE IS RESTRICTED TO THE TINTS OF DEAD LEAVES.

COMMON FROGS OF AFRICA

THE GREAT CREATURE ABOVE IS SO ADAPTED TO AQUATIC LIFE THAT IT RARELY VENTURES ON LAND. BELOW IS AN ENAMEL-GREEN FROG FROM A BANANA. TREE FROGS OF THIS GROUP WERE MOST ELUSIVE THOUGH THEIR RINGING CALLS WERE FREQUENTLY HEARD IN THE FOREST.

climbed a palm and gave us cocoanuts to assuage our thirst: Tabula, my Mganda servant, having drained a nut of its milk, turned to smash it against the stem of the palm. Immediately cries of protest arose from the group of local natives who had gathered round. "Why not?" queried Tabula, surprised, to which our host replied, "The palm tree says: 'You have drunk of my milk, now you beat me without cause, well, I'll show you,' and drops a cocoanut on your head." At Mbanja I had seen two corncobs, tied together by string, hanging on the bole of a cocoanut palm owned by an intelligent headman. "To insure fertility?" I queried. "Yes," he replied, "it is to make the tree bear better."

Monday found us all eager for the climb to Rondo Plateau. A casual remark, which some one had made to me in Lindi to the effect that a forest officer had recently spent several months surveying a reserve up there, decided me to include this patch of forest in my itinerary, for a lumber company was negotiating for a concession to remove the huge *mvuli* trees which were its greatest asset. Striding along the narrow path which traverses the length of the plateau, I encountered a limbless lizard and then a soft-shelled land tortoise lying dead. This was a good augury, for neither species had been met with during the course of this particular *safari;* the skink, a *Melanoseps*, was distinctly rare.

Our tents were pitched on a camp site cleared by the forestry officer the previous November. At that time three lions had been making themselves obnoxious to the Rondo Mission, which we had passed some hours before. The lay brother had trapped one and on going to shoot it had wounded another when it dashed up and clawed at the trap that held its companion. The survivor had gone on to the forestry camp and in snooping 'round, got under the tent-ropes, took fright and decamped.

Having reduced two loads by feeding my family of fifty porters, we turned in early, and were on our way shortly after dawn the next morning. On reaching

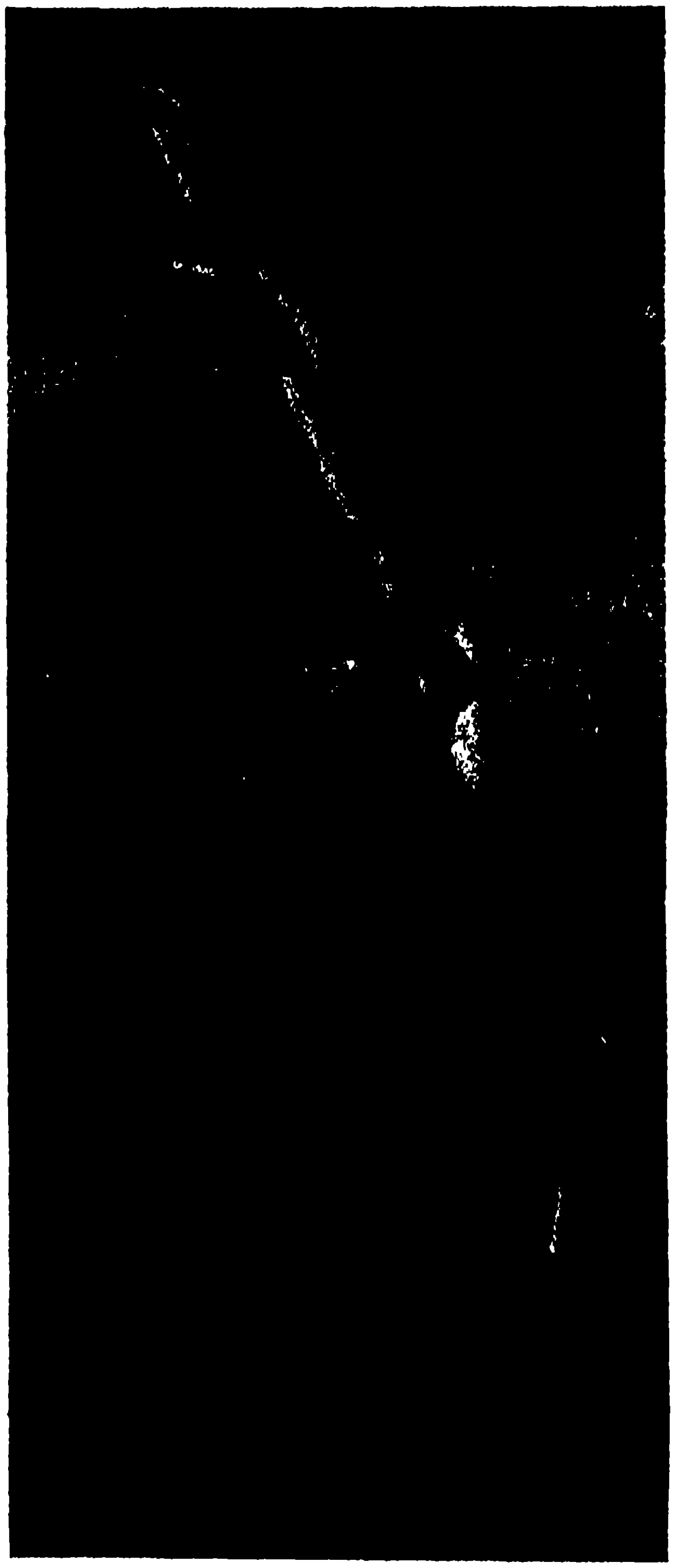
the forest, we found a spacious clearing and a well-built, but empty, hut. We soon had the latter open and a fire made, while tents were being pitched. Here, at nearly 3,000 feet, the climate was delightful, and my tent, set thirty feet back from a thousand-foot escarpment, commanded a magnificent view of the forested slopes opposite, for the plateau is shaped like a horseshoe at this point. Each morning the view was obscured by a solid wall of vapor that never blew away before 9 A.M.; every night this vapor was wafted up, condensed on the trees high above my tent, and, with each gust of wind, showered like pellets upon the awning. Water is something of a problem for none is to be found upon the plateau and it was necessary to send to the foot of the escarpment for it. The nearest natives were nearly three miles away.

The morning after our arrival a forest guard appeared. "Yes," this was his hut, he had abandoned it because he got tired of the lions. They *would* use the clearing for a playground and then come sniffing round the hut. "No," it wasn't just once or twice, but every night. It was only a matter of time, he thought, before they would be sufficiently hungry to break in. Hadn't we heard that a child had been taken on Friday, and a man within the month? Well, we hadn't, but neither had we been camped there a week before a boy of twelve, son of the *mwalimu* (local headman), was taken in broad daylight. The lion dashed into a hut, seized the lad and made off with him. Fortunately the boy's parents were also in the hut and raised a hue and cry; the boy, or his body, was recovered, but the lion escaped.

Rondo Plateau surpassed all previous camps in interest; this isolated remnant of forest contained forms which were closely related to the Usambara fauna, 250 miles to the north. It was with regret that I returned to Lindi, a township far too clean to be productive of much "vermin." While awaiting the arrival of the *S.S. Dumra*, our persistent efforts met with one success in the finding of

AFRICAN RODENTS

ABOVE IS A DORMOUSE OF THE EASTERN CONGO, WHICH LIVES IN THE BANANA PLANTS AND MAKES A DELIGHTFUL PET. THE HARSH-FURRED, RUFOUS-COLORED COMMON RATS OF THE VARIETY SHOWN BELOW, ARE FOUND ON MOST OF THE MONTANE MASSES OF EAST AFRICA.



A SLENDER SKINK
THE SKINKS OF IDJWI ISLAND HAVE BEEN HONORED BY A SPECIAL NAME, BUT ONLY DIFFER IN THEIR RICH COLORING OF RED AND ORANGE, FROM THEIR ALLIES ON THE MAINLAND.

two little Oriental burrowing snakes (*Typhlops braminus*) under some rotting thatch. These constituted the fourth and fifth records respectively for its occurrence in East Africa.

On landing at Tanga, we made our first camp by the ragged remains of forest surrounding the Siga Caves on the Mkulumusi River. According to native reports, these caves extend for half a mile through the limestone, and a party of Germans went in and never came out—a story probably devoid of truth. At any rate, the eerie neighborhood furnished us with the noisiest nights of the whole trip: the sharp staccato "barks" of hyrax on the cliffs, the wild unearthly cries of the galagos, and the hooting of owls doubtless contributed to the sinister reputation and prestige of the spirits which are said to dwell in caves.

Three times during our brief stay medicine men passed through our camp to perform rites at the entrance of the largest cave. One *mganga* was a very modernly-attired gentleman in fez, khaki shirt and shorts, a waterbottle at his belt. One patient was a sick woman brought on a wheel-barrow, accompanied by a man, probably her husband, bearing a white cock. The latter was beheaded at the entrance and left there after rites which lasted more than an hour. Another patient brought twenty eggs, I was told. Had I known this earlier I should have appropriated them, for we had had considerable difficulty in getting eggs. This would have afforded satisfaction as evidence that the "spirit" had accepted the gift! On our first visit I salvaged for the Peabody Museum the single horn of Grant's gazelle which we had found stuck in the entrance. There were feathers of several luckless fowls and two cents, which I presented to my companions who accepted them with considerable hesitation. The spirit was supposed to accept these offerings, but it was army ants (*siafu*) which I found consuming the white cock, and I fancy that leopards accounted for most of the other fowls.

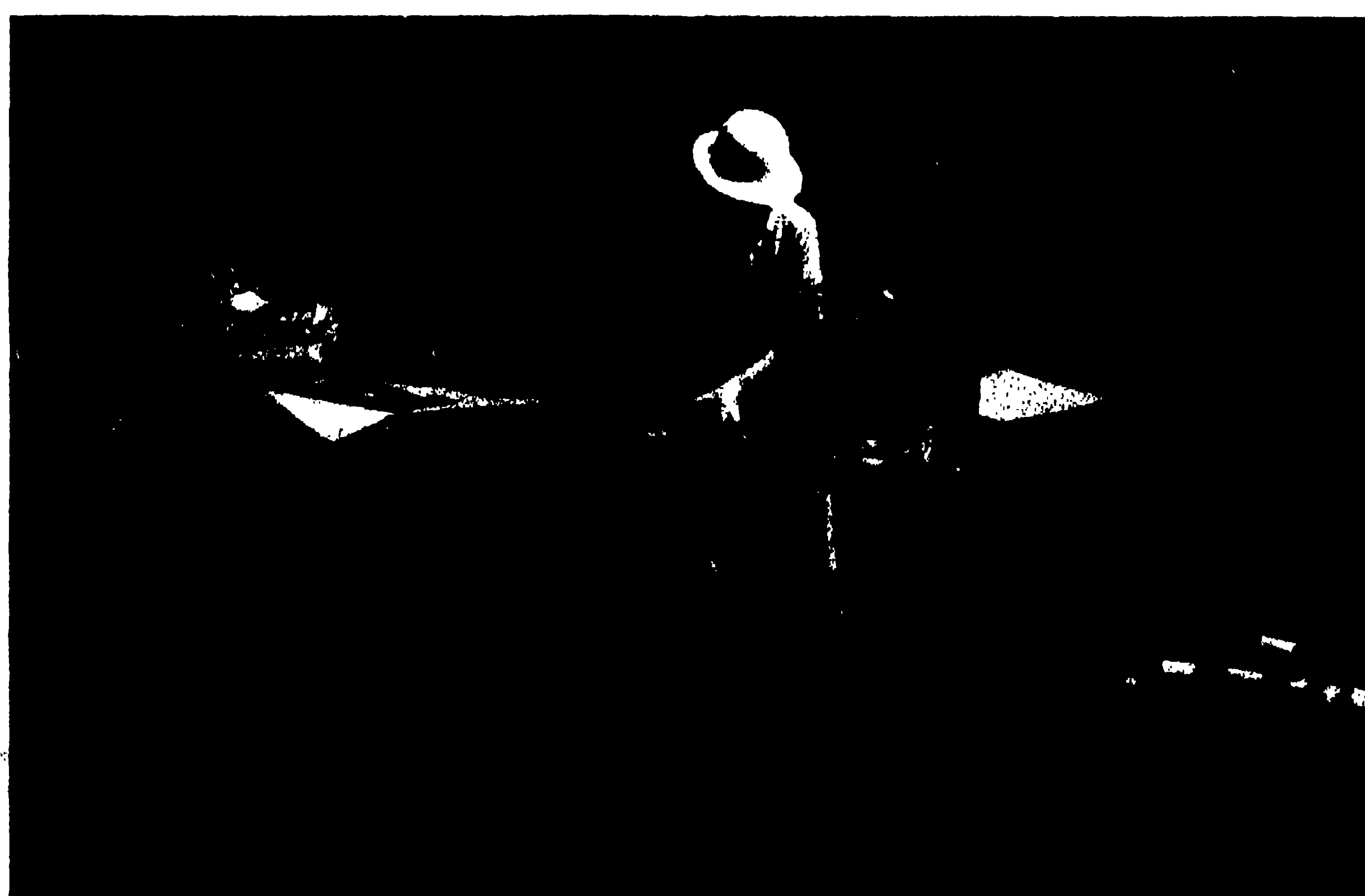
It was the bats, however, which interested me; thousands of them had their home in the lofty water-worn passages. We soon located them in a side passage where they were hanging at a height of about sixty feet above a stagnant, stinking pool. It was rather a problem to shoot them so that they would fall in the

shallow end from where it would be possible to recover them with the aid of a butterfly net. Outside the caves I netted four other species, and one evening in the gloaming I shot my first bat-hawk (*Machaerhamphus*) as it dashed hither and thither. In its stomach was a free-tailed bat of a species abundant in the caves. It had been swallowed whole, as is customary with these hawks whose wide gape makes them to bats what a nightjar is to moths.

While camped at Siga I received a visit from Mr. Hugo Tanner, of Amboni and other estates. He showed me the greatest kindness, as did all the members of his staff. Mr. Keller drove me about to inspect the principal patches of forest remaining on the Amboni Estate, which covers nearly eighty square miles. This enabled me to select a suitable site to which my camp could be moved without delay. Returning from this run, I shot a hawk (*Kaupifalco monogrammica*) from whose stomach we recovered a recently swallowed and quite undamaged example of the rather uncommon blind-snake (*Typhlops u. unitaeniatus*), the only one of its species procured during the trip. This elongated species reverses the normal pigmentation of creatures by being chrome above and uniformly black below.

The following week, having moved to Amboni in the meantime, I shot an eagle (*Circaetus cinereus*) which had swallowed four large snakes referable to three species, of which one was a night adder. The largest, a hissing sand-snake, measured quite four feet in length. In this way we continued to gather information about predators, prey and parasites, and our field-notes accumulated.

In due course I left Amboni for Magrotto Estate on Magrotto Mountain, which is close to the Usambara Range.



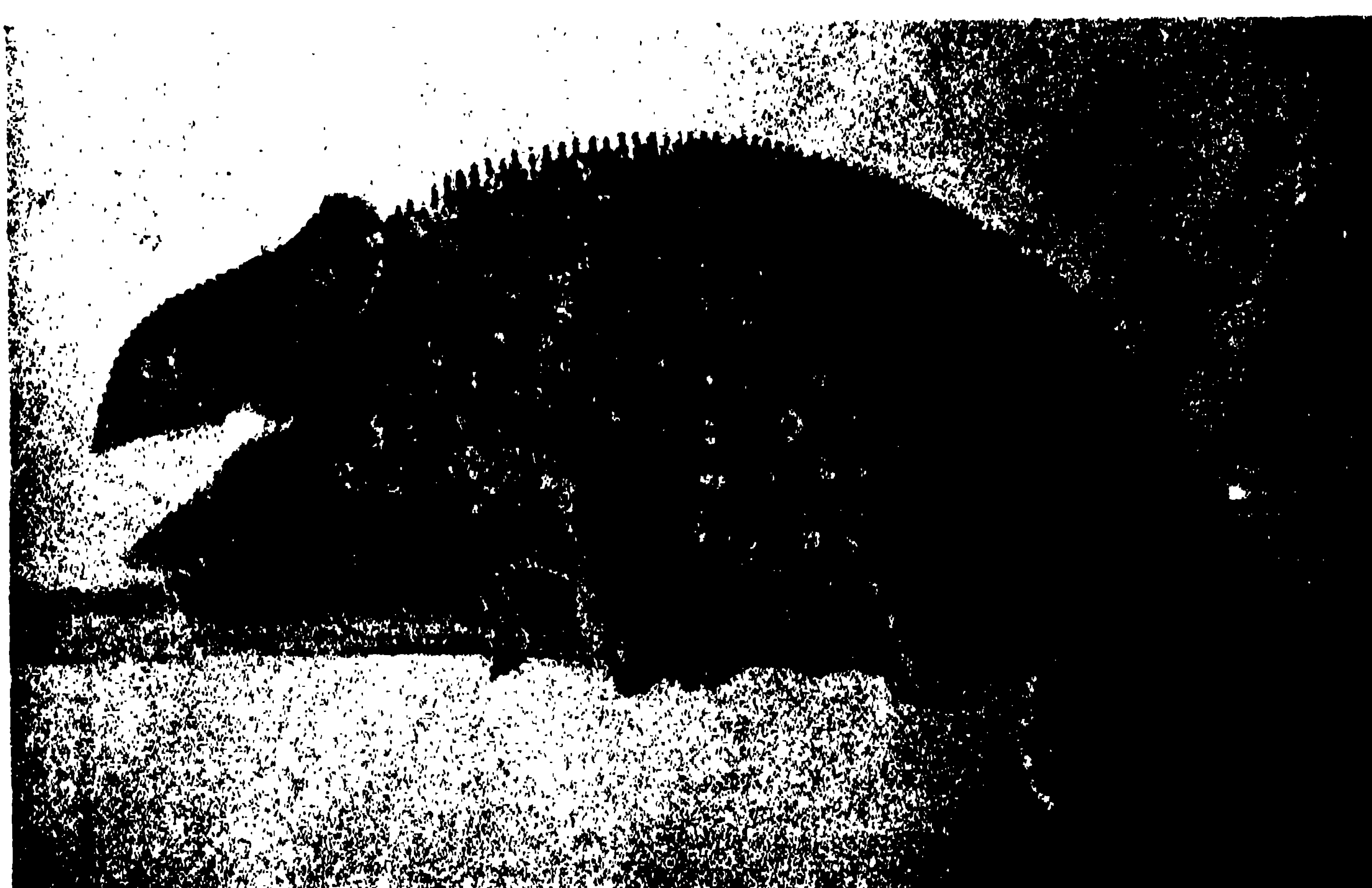
BABES AND BOTANICAL PURSUITS—A DAILY COMBINATION

DURING THE THREE-WEEKS STAY ON IDJWI ISLAND, THESE YOUNG PEOPLE VISITED OUR CAMP, THEIR PRINCIPAL INTEREST BEING TO WATCH MY WIFE ENGAGED IN THE TEDIOUS TASK OF CHANGING DRYING PAPERS IN HER PRESSES.

The lorry climbed the steep escarpment road with considerable difficulty, backing and filling at the hairpin bends which could not be negotiated in any other way. At 2,000 feet, or thereabouts, we ran into trouble, for heavy rain had fallen the night before and the wheels spun futilely on the slippery clay. After several such delays I walked on, expecting to be overtaken. An hour passed, however, so that I reached the hospitable home of the manager long before the lorry. Here Mr. and Mrs. C. Clausen asked me to tea and invited me to spend the night. I needed little urging, for wisps of fog were creeping about, and it seemed raw and chilly as a November day in England.

Next morning my host conducted me to a delightful camp site. It was on a crest situated in a semicircle of forest-capped ridges. The immediate vicinity was planted with oil-palms, for Magrotto is the only plantation of these palms in East Africa. With its well-kept terraced paths winding through the orderly lines of these ornamental trees, it gave one the impression of dwelling in a park or arboretum.

On arrival I had noticed beside the paths an occasional stone surrounded by the broken shells of the nuts—much as a litter of snail-shells lies about a stone which has served as anvil for some thrush. Later I saw that there was usually a small second stone nearby, a *pied de main*, as it turned out. For one day, when walking quietly back from a trip of investigation in the nearby forest, I heard the sound of intermittent tapping. Presently I descried a fat little darky, scarcely four years old, sitting on the path, his back toward me, guzzling the kernels, as he kept a more or less watchful eye on his mixed charges, a flock of sheep and goats which were feeding among the palms. Thus I realized how it came about that the plantation pickaninnies were so sleek and tubby.



A HANDSOME HORNLESS CHAMELEON, GREEN IN COLOR WITH ORANGE SPOTS

THIS CHAMELEON WAS NOT UNCOMMON IN THE EXTENSIVE COFFEE PLANTATIONS SOME MILES FROM CAMP ON IDJWI ISLAND IN LAKE KIVU.

AN EMIN'S WORM SNAKE FROM BUNDIBUGYO AND A BURROWING SKINK

THE FULL-GROWN, TERMITE-EATING REPTILE AT THE LEFT, IS OF THE SAME GENUS AS ITS NORTH AMERICAN COUSINS AND FORMS A LINK WITH EMIN PASHA WHO WAS ITS FIRST DISCOVERER. IN THE SECOND PICTURE, NOTE THE BUD-LIKE FORE LIMBS AND THE VESTIGIAL HIND LIMBS OF THE SKINK. THIS PROBABLY UNDESCRIBED SPECIES INHABITS SANDY SOIL WHERE IT COMES TO THE SURFACE BENEATH PILES OF ROTTING VEGETATION.

It was with regret that I started to pack up in preparation for leaving Magrotto. Not only was it the last camp of the trip, but it had furnished nearly fifty different kinds of reptiles and amphibians, and here the best oranges in the world might be had for a cent each, *i.e.*, 400 for a U. S. dollar! I had been starved for vegetables for the greater part of the tour, but while here the Claussens kept my table well supplied from their flourishing garden. 'Tis true that we had experienced much wet weather at Magrotto, but rain had fallen at least once during every week of the nine months occupied by the *safari*, so we had become almost indifferent to it.

The fourth, and final shipment of specimens for the States, making about a ton and a half in all, was turned over to the agents, and then the last two days ashore were passed at the Tanga Hotel, where my wife and I had stayed twelve years before on our return from the Usambara expedition. Now it was under the able management of Mr. and Mrs. Peter Roach, and as comfortable and well-equipped as any traveler could wish. Down the main road passed a company of King's African Rifles, equipped with the latest type of death-dealing weapons, such as Bren guns. As they returned from their route-march they sang some Kiswahili equivalent of Tipperary: it made one realize that we were back in civilization again! Germany was planning the invasion of Poland; Europe, it was rumored, was on the brink of war.

Next evening we boarded the *M.V. Dunbar Castle* which was to carry my Baganda to Kilindini and myself away from Africa. The *Dunbar Castle* which, within a few months, was destined to strike a mine and be sent to the bottom.

THE PERILS AND ROMANCE OF SWORDFISHING

THE PURSUIT OF *XIPHIAS GLADIUS* WITH THE TRIDENT IN THE STRAIT OF MESSINA

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INTRODUCTION

THE swordfish is found in many waters the world around, and, because of the excellence of his flesh as food, is captured by many peoples using various methods. However, the chief instrument of his capture everywhere is the harpoon. In these harpoon captures there is much of romance, and because the fish is provided with a great broadsword—the most extraordinary weapon given to any fish—there is also peril in these encounters. This great and powerful fish was known to the earliest dwellers along the eastern and northern shores of that sea—the Mediterranean—which in classical times was well named "the sea in the middle of the lands." For in those early days the known world was practically composed of those countries which surrounded this great sea. These Mediterranean peoples knew, captured and ate this great fish. Furthermore, the Greeks being gifted with vivid imaginations, which were provoked by its lethal weapon, invented a mythical explanation of the origin of fish and weapon.

THE LEGENDARY ORIGIN OF THE SWORDFISHES

That the *galeote*, or swordfish, was known to the inhabitants of the eastern Mediterranean many centuries before the Christian era is indicated by the romantic mythological story of its origin. It is alleged that when Achilles voyaged to Troy to aid Menelaus in seeking revenge for the abduction of his wife Helen, he went as leader of the Myrmidons. When Achilles had been treacherously slain by Paris, they rushed against the Trojans to avenge him. But when these refused to come out and join battle, the Myrmidons in bitter grief, sudden rage and blind fury threw themselves into the sea. However, Thetis, the mother of Achilles, took pity on them and changed them into fish; and since they were fighters, into fish that were allowed to retain their swords as long spikes projecting forward from their upper jaws—as swordfish.

THE SWORDFISH AND HIS NAMES

If there is any basis in this legend for a very ancient knowledge of the swordfish by the Greeks, it seems to be clear that from the very earliest times they regarded him as pugnacious and warlike. But turning from legend to fact, as Fig. 1 shows, this great and splendid fish is beautifully streamlined from sword-point to tail-tip and is built throughout on racing lines—even his dorsal fin has an elegant "rake." He is a living torpedo, evidently capable of great speed. With his broadsword-like bill he is surely armed for war and is aptly named "swordfish."

The extraordinary prolongation of the upper jaw attracted the attention of the ancients and surely led to their assigning characteristic names to the fish. The Greeks called him *Xiphias*, and the Romans *Gladius*—each name meaning sword. And we moderns have adopted both names and call this fish *Xiphias gladius*—thus doubly (in two languages, naming him the swordfish. But

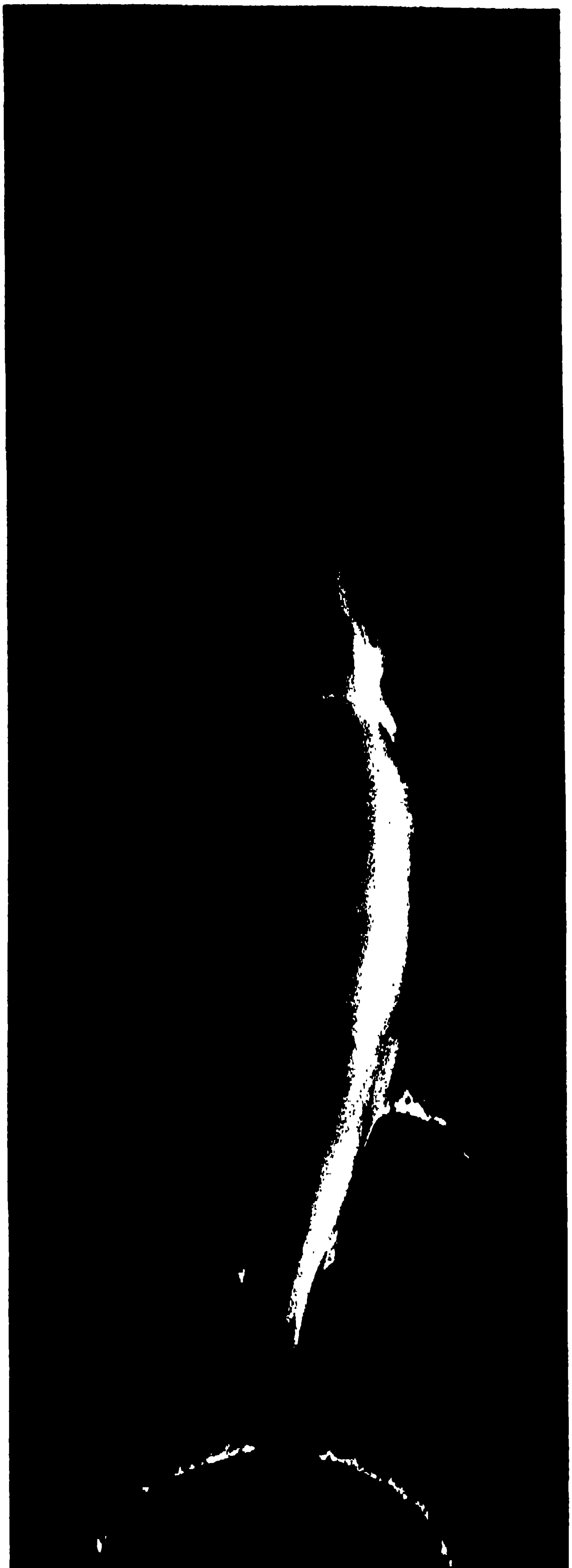


FIG. 1. BROADBILLED SWORDFISH
AMERICAN MUSEUM MODEL OF MICHAEL LERNER'S RECORD ATLANTIC SWORDFISH—13½ FEET LONG AND 601 POUNDS IN WEIGHT.

since *Xiphias* has a long, broad, flat, smooth sword, he is called the ***broadbill*** to distinguish him from the *spearfishes*, the marlins and sailfishes, which have *round bills* with blunt tooth-like bodies on the under side of their relatively short spikes.

The cognomina given our fish all play upon the sword theme. His name in all languages is a translation of the word swordfish. These names are too numerous to list here, but it may be noted that the Italians call the fish *Pesce Spada;* while the French name him *Empereur, Imperator, Epée de Mer* and *Espadon.* And we to-day dub him the "ocean gladiator." All names go back to the fact that the fish bears a straight double-edged sword (Fig. 1), and it will be remembered that the Roman emperor was always represented with such a drawn straight sword in his hand. The swordfish found in the Mediterranean and known to the ancients is surely *Xiphias gladius.* And even as the Roman despot was supreme over the far-flung lands surrounding the Mediterranean, so *Xiphias* was supposed to rule over the watery empire of that sea.

Xiphias Given a Bad Reputation

The ancients, having given our fish his characteristic names, proceeded to assign him a character according. They gave him a "bad name" and attributed to him a choleric and pugnacious temperament.

Thus, earliest of all, Sophocles, the Greek tragedian (496–406 B.C.), speaks of our fish:

> What Fury, say artificer of ill,
> Arm'd thee, O Xiphias, with thy pointed bill?

And Oppian (172–210 A.D.) in his "Halieuticks" (the English version of his "*De Piscatu*") speaks of Xiphias as "the Swordfish armed for War," says that the "hardy Swordfish wields the threat'ning Blade," speaks of its "murd'rous Use," affirms that he is

"Extravagant in Folly and in Fear" and concludes that

> Nature her Bounty to his Mouth Confined,
> Gave him a Sword but left unarm'd his Mind.

And in another place, evidently referring to the fishermen who harpoon him, Oppian writes of Xiphias that,

> With impotent Revenge his useless Sword
> Assaults the Boats, and stabs the treach'rous Board.

This opinion seems to have been held by many other classical writers who record the attacks of Xiphias on vessels in transit. And it must be confessed that the combination of long sword, huge eye and large stout body do give our fish somewhat of a sinister appearance (Fig. 1).

This belligerent reputation persists unto the present day. Thus one writer (in 1854) spoke of Xiphias as having "a sword . . . of a temper like that of its owner, neither to be trusted nor trifled with." And the outstanding modern writer on our fish said in 1883 that "the pugnacity of the Swordfish has become a by-word." Another (and more recent) author speaks of the "choleric disposition" of Xiphias, and another writes that "It surely seems as if a temporary insanity sometimes takes possession of the fish."

From this it is plain that the modern, as well as the classical, writers have given *Xiphias gladius*, the broadbill, a "bad name," and it must be confessed that there is some reason to justify them in what they have written. However, as will now be shown, Xiphias is given a sword, not that he may avenge himself on those who seek with the harpoon to capture him for food, but for a more prosaic purpose.

The Sword of Xiphias Used for Getting Food

From far antiquity down to the present time it has been known that Xiphias feeds on the dolphin (fish, not mammal) and his kind. Thus, earliest of all, Oppian states that, "To crested Horsetails hungry Swordfish haste," but gives no hint as to how the dolphin is secured. Now the sword of Xiphias is not primarily a weapon of warfare but is given him as an organ of food-getting. He has a large mouth but no teeth, and it is only possible that by swimming rapidly and wide-mouthed into a school of small fishes, herring, mackerel, etc., such as he feeds on, Xiphias might engulf many. But he has been seen to rise in schools of such fishes and by falling sidewise among them to stun many. He is known also to slash with his sword right and left in a school, disabling scores of fish, which are picked up at leisure.

The swordfish has been reported sometimes to toss his prey in the air or to impale larger fishes on his weapon in true gladiatorial style. This has been recorded by at least one scientific man (Bennett, 1840) as a personally observed fact. He writes thus:

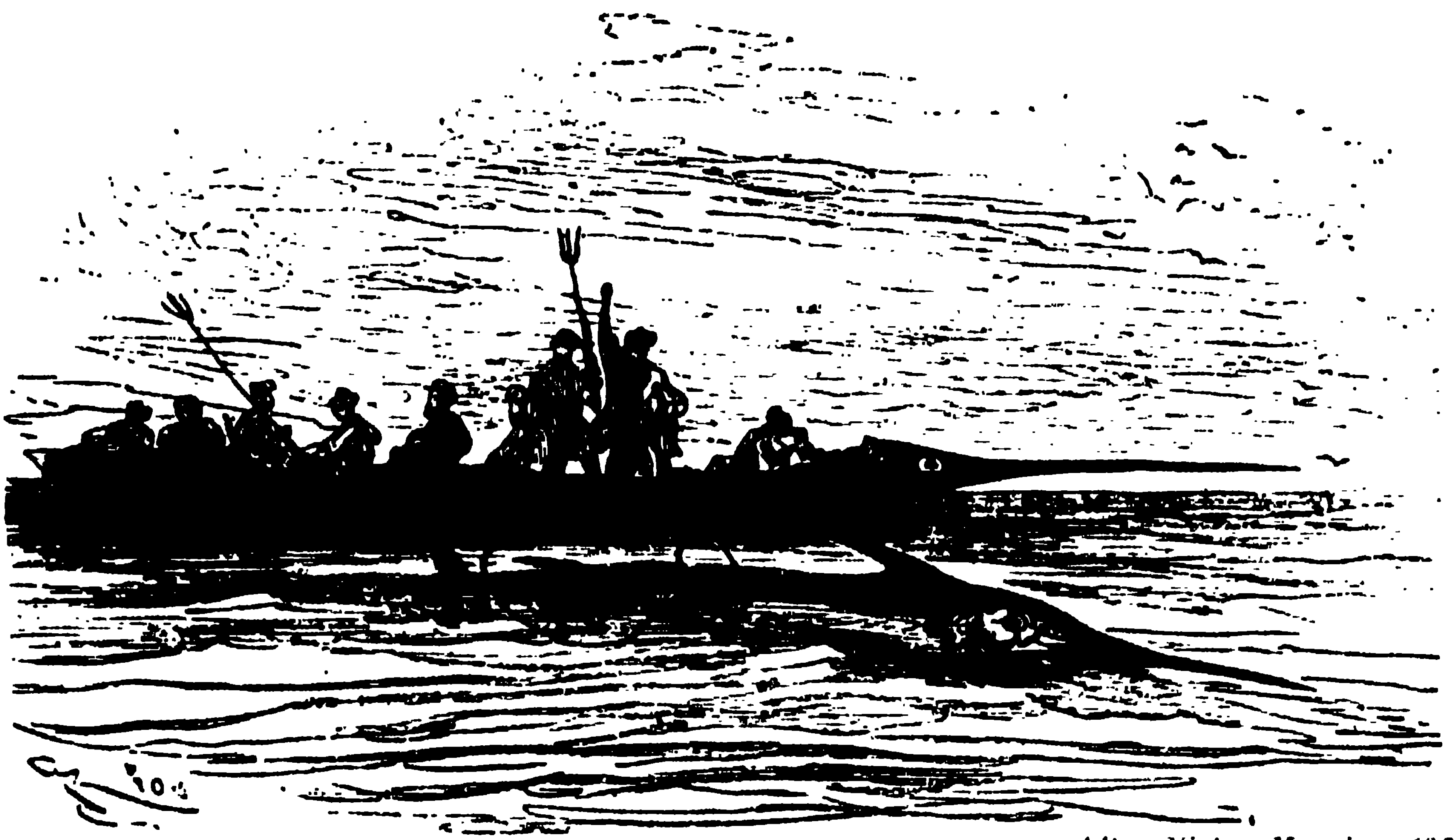
> The swordfish . . . subsists by making rapid darts amongst a school of . . . fishes, and after transfixing as many as possible on the beak or sword . . . shaking them off by a retrograde movement, or by moving the sword from side to side, and devouring them. I have seen a swordfish thus strike and devour three bonita, in a very dexterous and rapid manner.

This shows that Xiphias is an adept in the use of his weapon.

Xiphias Used for Food in Far Antiquity

Xiphias in turn is preyed upon by sharks and by man—by whom his flesh is highly prized.

If there is any basis for an early knowledge of the swordfish in the Trojan legend of his origin, then it seems probable that in far distant times Xiphias was used for food in the eastern Mediterranean. Of this we find evidence in the "Banquet of the Learned" of Athenaeus of Naucratis, an erudite Egyptian, who flourished about 200 B.C.



After Victor Meunier, 1868.

FIG. 2. FISHING WITH THE SWORDFISH-SHAPED BOAT

NOTE THE ELONGATE PROW CORRESPONDING TO THE SWORD, AND NOTE ALSO THE PAINTED EYE. THE OARS CORRESPOND TO THE FINS, AND THE RUDDER OR STEERING OAR TO THE TAIL OF THE FISH.

In the course of this banquet, which is reputed to have taken place in the house of Laurentius, a noble Roman, Athenaeus advises that the gourmand-traveler,

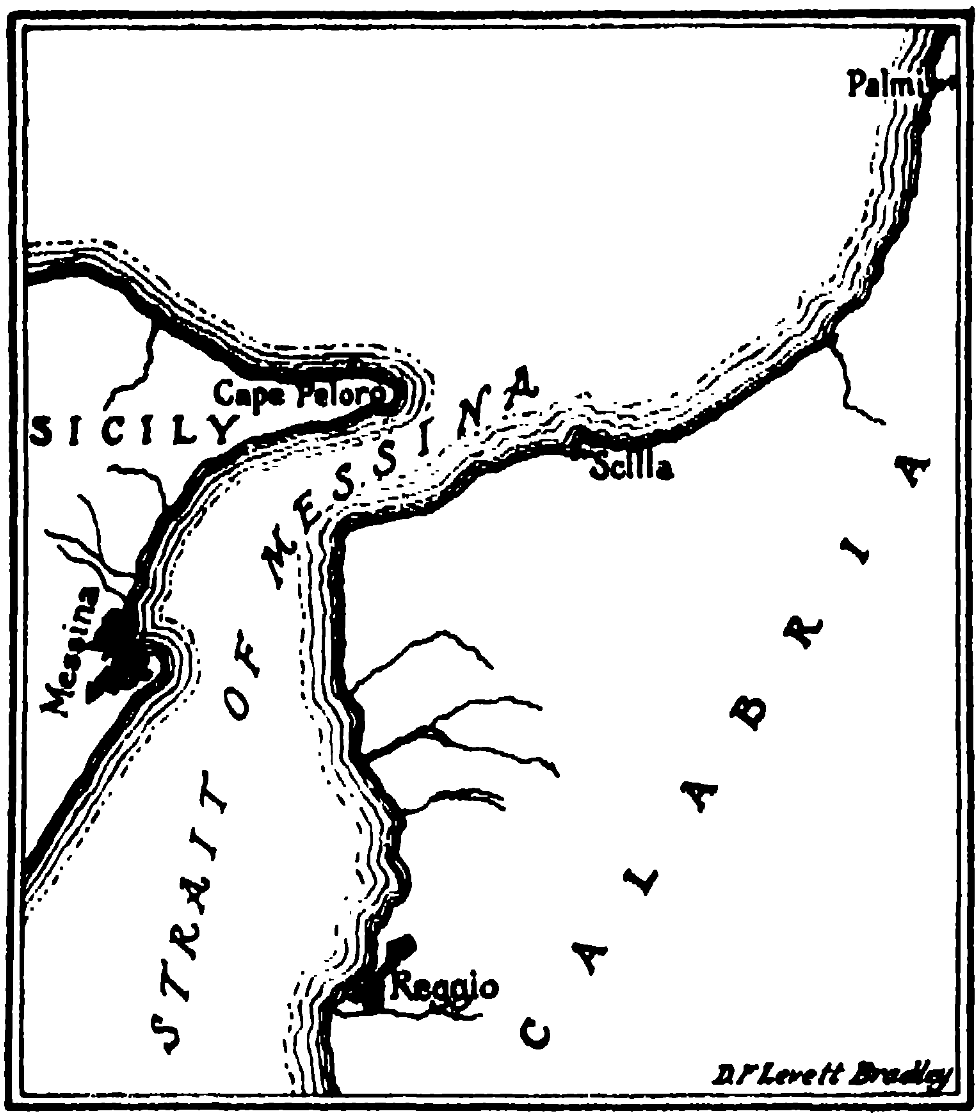
> Take a slice of swordfish when you go
> To fair Byzantium, and take the vertebrae
> Which bends its tail. He is a delicious fish,
> Both there and where the sharp Pelorian Cape
> Juts outward toward the sea.

Athenaeus was a prodigious and multifarious reader, and the great value of his book is that in it he has by copious quotations preserved large fragments of the works of ancient writers, which but for him would have been lost. Thus the above is a quotation from the Greek poet Archestratus, who lived about 350 B.C. and wrote a poem on "Gastronomy"—the major portion of which is lost. Archestratus lived in Sicily and must have known the swordfish in the Strait of Messina, since the Pelorian Cape is on the west side of the strait and only about eight miles from Messina.

I have introduced Xiphias to the reader and have briefly given somewhat of the "romance" of his legendary origin, of his names and reputation, of his use as food at least twenty-four centuries ago and of the normal use of his sword. And now the reader shall learn of some uses of his sword that justify the inclusion of the term "Perils" in the title. And, with old Archestratus, we shall look out upon that strait which had the rock Scylla on one side and the whirlpool Charybdis on the other. To these waters comes our great fish, in the words of an unknown writer:

> Fleeing from the northern countries,
> Comes the monstrous Xifia, proud
> Of its great sword, from Italy
> To the happy shores, and quickly
> Cutting the Tyrrhenian waters,
> The curved Pelorus doth approach.

Off this cape and in this strait, as for two thousand years past so to-day, the swordfish, called *pesce spada* by present-day dwellers in those parts, is eagerly sought for food. But first the reader and I will learn of the earliest fishing there for Xiphias for food.



Redrawn from a chart by courtesy U. S. Hydrographic Office.

FIG. 3. THE SWORDFISHING REGION OF THE STRAIT OF MESSINA. ON THE EASTERN SIDE NEAR SCILLA THE FISHING IS IN RELATIVELY DEEP WATER CLOSE IN SHORE. NORTH OF SCILLA AND IN THE SOUTHERN PART OF THE STRAIT ON BOTH CALABRIAN AND SICILIAN SIDES, THE FISHING, BECAUSE OF SHALLOWER WATER, IS FURTHER OFF SHORE.

The Earliest Swordfishing Story—in the Strait of Messina

The earliest of all the classical accounts of the perils and romance of swordfishing was written about 100 B.C. This comes from Polybius, the Greek historian of Rome. This part of his "History" is no longer extant, but fortunately it has been preserved by Strabo (63 B.C.–21 A.D.), the "Father of Geography." This fishing was in the Strait of Messina, at Scyllaeum on the mainland side. As will be noted, it is essentially the method practiced there to-day—two thousand years later—and the prototype of the practice of our New England and Nova Scotian fishermen to-day. Strabo's account is the very oldest on record and must be considered carefully.

> One lookout [on the rock Scylla?] directs the whole body of fishers, who are in a vast number of small boats, each furnished with two oars and with two men to each boat. One man rows, the other stands on the prow, spear in hand, while the lookout [on the cliff] has to signal the appearance of a swordfish. (This fish, when swimming, has about a third of its body above water.) As it passes the boat, the fisher darts the spear from his hand, and when [the staff of] this is withdrawn, it leaves the sharp point with which it was furnished sticking in the flesh of the fish. This point is barbed and loosely fixed to the spear [handle] for the purpose; it has a long end [of line] fastened to it; this they pay out to the wounded fish till it is exhausted with its struggling and endeavors to escape. Afterward they trail it to the shore or, unless it is too large and full-grown, haul it to the boat.

Surely this is romantic—the lookout on the high rock Scylla (about two hundred feet above the water), the little boats dancing on the waves in the brilliant sunlight, each with but two men, a rower and a harpooner, to tackle the great and much-feared fish. But there was peril as well as romance, and of this Strabo also writes:

> It sometimes happens that the rower is wounded [by the harpooned fish] even through the boat and such is the size of the sword with which the galeote [the swordfish] is armed, such is the strength of the fish, and the method of capture, that [in danger] it is not surpassed by the chase of the wild boar.

From this it is seen that swordfishing is an ancient occupation—having been practiced probably hundreds of years before Christ—and a dangerous one. This earliest known account of swordfishing, written by Polybius about 100 B.C., illustrates both the romance and the perils—two men (one armed with a puny dart) in a fragile cockle-shell of a boat in the strait between the dread rock Scylla and the even more dreaded whirlpool Charybdis, the whole outfit of men and boat weighing hardly more than the huge marine gladiator which they were attacking. Surely this fishing called for courage and daring of a very high order.

Fishing from the Galeote-Shaped Boat in the Mediterranean Sea

But as time and swordfishing went on

in this region, a new and improved method of taking Xiphias was perfected. The Roman writer Aelian, who flourished 120 A.D., gives the first hint of this most extraordinary fishing method. In his book on animals he says that when the swordfish has attained its full growth, "its sword may be compared to the beak of a trireme" (a galley rowed with three banks of oars). And when of this size that "it ventures to attack a vessel fashioned in the shape of [itself and] its own beak." This is but a hint, yet it indicates that the Romans of Aelian's day hunted Ziphias in a boat shaped like a swordfish (a galeote).

Not a hint but a clear statement is given by the poet Oppian (172–210 A.D.). After describing how Xiphias is taken on the hook (the earliest known reference to this method), Oppian goes on (in "Halieuticks," as translated by John Jones, Oxford, 1722) to describe the fishing from swordfish-shaped boats in the western Tyrrhenian Sea:

> The Western Gaul, Etruria's happy Swain,
> And whom Massilia's sacred Walls contain,
> Unusual Scenes of Strategem ordain.
> There vast enormous Lengths of Sword-fish glide,
> In Nature Fish but Monsters all beside.
> With mimic Form their Boats convex they bend,
> Display the Fins, the threat'ning Sword protend.
> The joyful Fish his new Companions greets,
> Herds with the Throng, nor sees the gross Deceits.
> The Silent Fishers form a Circle Round,
> The Trident dart and strike the triple Wound.
> Now undeceiv'd he feels the fatal Cheat,
> And struggles, fond of Freedom and Retreat.
> With impotent Revenge his useless Sword
> Assaults the Boat, and stabs the treach'rous Board,
> Wedg'd in the Wound; but soon the steely Blow
> Of Arms and Life at once bereaves the Foe.
> . . . .
> Like them the Boats familiar Shapes assume:
> 'Tis feigned Acquaintance brings the surest Doom.

The faint allusion to the shape of the boats in Aelian is here made very definite and clear. So, hoping that there might have come down from Roman times on painted vase or mosaic wall a picture of one of these swordfish boats, I have worked through many volumes on Roman antiquities, but no such picture has been found. However, I have found pictures of war galleys with rams in front shaped somewhat like the swordfish's sword and, in the region of the modern hawseholes, with eyes painted such as are found to-day on Chinese junks. Possibly these galleys were patterned after our swordfish.

One other faint reference to the Xiphias-shaped boat is found in a description of swordfishing off Scylla, dated late in the 1600's. Father Niccola Giannettasio, of the College of Reggio in Calabria, speaks of seeking the "Xifia" in the "painted boat" but gives no details.

Various modern authors refer to this ancient use of the Xiphias-shaped swordfishing boat, but only one goes into any detail. Victor Meunier in his "Les Grandes Pêches" (Paris, 1868) reproduces his artist's conception of this boat (Fig. 2 herein) and writes thus of this exceedingly clever and most interesting method of taking Xiphias:

> One of the methods in use among the Greeks consisted in employing barques modelled after the form of a swordfish, provided with a pointed prow which represented its [elongate upper] jaw, and painted in the dark colors which are peculiar to it. The swordfish approached [this boat] without mistrust, thinking that it saw a fish of its own kind [Fig. 2]. The fishermen, profiting by its error, pierced it with tridents. Although surprised, the animal defended itself with vigor, struck with its sword the planking of the deceitful barques, and often put them in danger [of sinking]. The fishermen took advantage of this moment to cleave the head of the fish and if possible to cut off the upper jaw. After having triumphed over the resistance of the fish and having possessed themselves of it, they lashed it behind the barque and brought it to land . . . This ruse was likewise made use of by the Romans. The fishing for the espadon was at that time one of the most important carried

After Victor Meunier, 1868.

FIG. 4. ANOTHER SWORDFISHING BOAT WITH MODERN ADAPTATIONS

THE STEM IS EXTENDED UPWARD TO THE LEVEL OF THE HARPOONER'S WAIST AND HAS A CROSS-PIECE OR REST FOR HIM TO LEAN AGAINST IN ROUGH WEATHER. THIS CORRESPONDS TO THE "PULPIT" OF AMERICAN SWORDFISHING BOATS.

on on the coasts of the Tyrrhenian Sea and of those of Narbonne in Gaul [bordering on the Mediterranean].

The faint allusion to the shape of the boat is made clear in Oppian's account and Meunier's figure (No. 2 herein), Here are the sword (ram), the eyes (like hawseholes), the fins (oars) and the tail (rudder or steering oar). When such a boat drew near to a swordfish, and when he turned a great eye upward, we can understand Xiphias thinking, "My big brother." Then, when he sidled closer, came the stroke of the trident, disillusionment, pain, anger and the return stroke against the deceiving boat.

Modern Swordfishing in the Strait of Messina

Swordfishing has been carried on off Scylla and all through the Strait of Messina since the days of Polybius, Strabo and Oppian. I have specific descriptions of such fishing under dates of 1673, 1798 and 1906 (two long accounts by Italian authors living at Messina). The methods described are outgrowths of those recounted by Strabo, showing a progressive perfection of technique. "After 2,000 years, this fishing remains just about the same, and the description of Polybius seems as if written yesterday." Brief descriptions with figures of present-day fishing may be of interest.

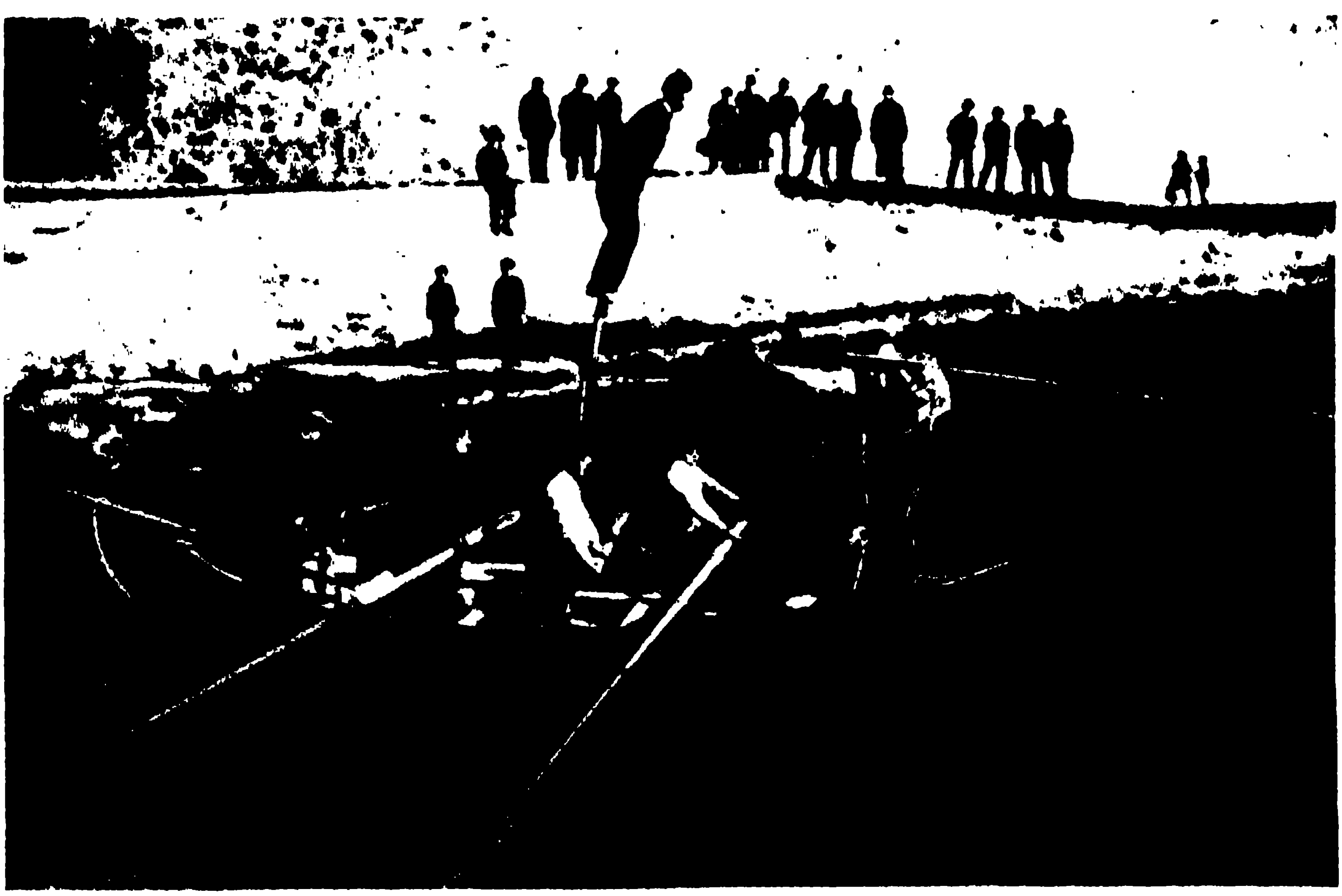
But, in order that the reader may have a clear idea of the "lay of the land," Fig. 3 is introduced—a sketch of the celebrated Strait of Messina, in which swordfishing has been carried on for over twenty centuries. On the mainland is Palmi, where the fishing begins. South of this is Scylla, at the eastern side of the entrance to the Strait, and on the west side, Punta del Faro (the Pelorian Cape). Further south is Messina on the Sicilian shore and Reggio

in Calabria. The fishing is mainly carried on in the waters thus delimited.

Under date of 1673, John Ray writes of the fishing that there are "Speculatores" on the cliffs of Scylla "to espy the fish," and there is an indefinite reference to the use of a tall mast in another book but no description of it. There are several oarsmen (number not stated). The greatest change from the simple method described by Strabo is found in the short mast (15–18 feet high) about the center of the boat, with cleats on it. On this stands another lookout, who takes directions from the "speculatore" where to find the fish, and so directs the rowers. When close on the fish, "he upon the mast comes down and taking the harping iron in his hand, if he can, strikes it into him. The fish being wounded, plays up and down and wearies himself," and the end comes soon.

By 1798 the technique of swordfishing in the strait had been so far perfected that it is almost identical with that described in 1906. Any differences in the methods of 1906 are simply refinements of those of 1798 and of 1673. The fishing off Scylla with its lookouts on the high rocks is of one kind. That on the lower Calabrian coast above and below Scylla, and always that off the Sicilian coast, is of another order. Each will be briefly described. But first it must be said that the fishing grounds throughout the entire strait are divided into "stations," to each of which one or more boats (of one company) are assigned. These in the beginning are determined by the lot, but to assure a fair chance to every boat or company, there is day by day a rotation of stations.

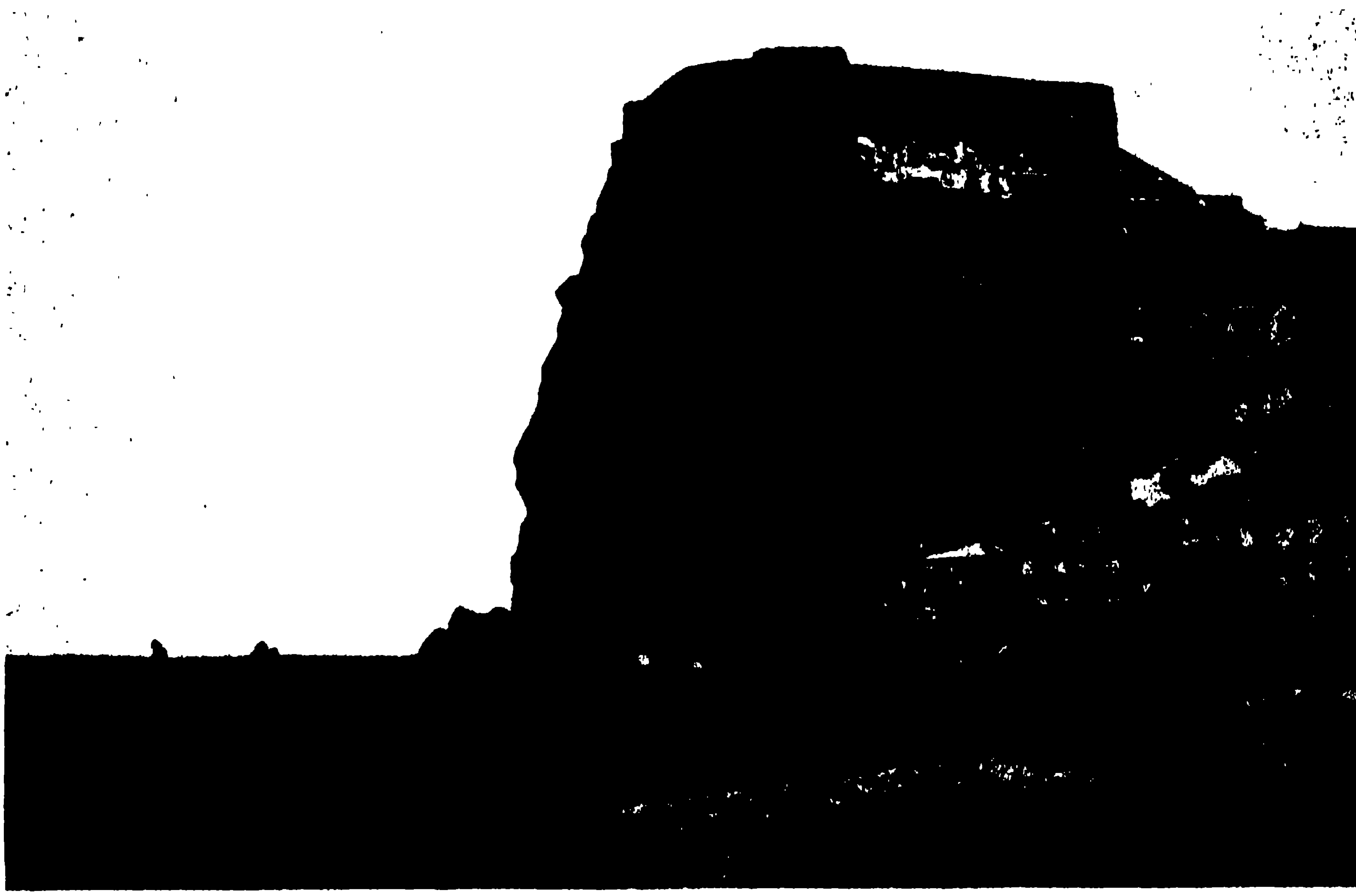
Before describing the technique of present-day fishing in the Strait, there must be interpolated here, under date of 1868, the figure and brief description



After a photograph by Mercadante, 1906.

FIG. 5. SWORDFISHING CLOSE INSHORE ON THE CALABRIAN COAST

THE BOAT IS DOUBLED-ENDED, THE OARS ARE OF UNEQUAL LENGTH; THE MAST-HEAD MAN DIRECTS THE COURSE OF THE BOAT, AND THE HARPOONER STANDS READY. ON THE NEARBY SHORE IS A GROUP OF INTERESTED SPECTATORS.



After a photograph by Mercadante, 1906.

FIG. 6. SWORDFISHING UNDER THE ROCK SCYLLA

THE FIGURE (MADE FROM A PHOTOGRAPH) SHOWS THE PROMONTORY, THE LITTLE TOWN ON ONE SIDE, AND ON TOP OF THE CLIFF AN OLD CASTLE. NOTE HOW CLOSE UNDER THE ROCK ARE THE FISHERMEN.

of a Mediterranean swordfishing boat unlike any described by any other writer on fishing for Xiphias in this sea. This is from Meunier, the French author elsewhere referred to. Apparently it was used in his time (1868), whether in Italian or French waters is not stated, but presumably off Italy. The boat is shown in Fig. 4, in which is seen what may be the forerunner of the rest or "pulpit", which is such a characteristic feature of American swordfishing boats. It is for this reason that this figure is inserted. However, strange to say, no trace of this remarkable "rest" can be found in recent figures of the fishing boats used in the Strait.

This boat is about twenty-five feet long, has a gunwale about forty-five inches above the water, a mast about eighteen feet high for the lookout, is wide enough for two oarsmen to sit on each thwart, and has a wide square stern. But most different from any other boat figured, is the fact that the stem is extended vertically upward and has at its top a crosspiece as a *brace* or *rest* at the level of a man's waist, against which the harpooner may steady himself in case of rough water. The crew is composed of eight oarsmen, the lookout and the harpooner.

Present-day Fishing off Scylla

The fishing here is done fairly close inshore. Lookouts ("speculatores") are stationed on the high cliffs overlooking the water or, if the shore is low, on towers varying in height (according to the elevation of the ground on which they are erected) from 80–150 feet above the water. Thus the land lookouts have before them the water of their respective stations or zones, which they ceaselessly scan for the fins of Xiphias swimming at the surface. The boats

are double-ended, and to facilitate rapid steering, so that the *pesce spada* may be easily followed in his "tours and detours", the oars are of different lengths —two long and two short. The long oars for ease of manipulation have outrigger oarlocks. In the center of the boat is a small mast (15–18 feet high) called *garrière*, having nailed to it crosspieces by which the mast-header ascends and stands on a little platform near the top. Such a boat is shown in Fig. 5.

The crew is composed of five or six men—three or four oarsmen, a lookout and a harpooner; but when there are six, the lookout (when the fish has been struck) descends and aids at the oars, pulling on one and pushing on another, to facilitate rapid turning to follow the fish in his "vertiginous course."

The lookout on shore by voice and by the waving of a white flag indicates where the swordfish is. The masthead man (*farière* or *filière*) directs the rowers how to follow the fish. The short oars are rowed steadily, but not so the long ones. One oarsman pulls forward, but the other backs (they are both aided by the extra oarsman), and thus the boat is turned in a very short radius. In this way the boat fairly easily follows the erratic movements of the swordfish, which seems almost to play hide and seek with the boat.

The special shape of the (double-ended) boat, the inequality in the lengths of the oars and the technique evolved in their handling, have brought it about that this boat has great speed as well as great manoeuverability, and have led to its being called *bersagliere del mare*, the "swift scout of the seas." When brought within twelve or fifteen feet of the fish, the harpooner may "pitch-pole" his harpoon with a slightly curved trajectory (Fig. 5), or if "put onto the fish", may strike it at short range (Fig. 8). In any case the stricken fish tires itself out dragging the harpoon shaft and long line behind it, and is then hauled up to the boat and killed. Sometimes, however, the shaft is retrieved by a warp tied to it.

This is a fair description of the method of fishing at or near Scylla. But Scylla is not the naked promontory it was in Strabo's or in Oppian's time. Tradition has it that on it there was once a temple to Minerva, but more worthy of belief is that in 1255 it was fortified by the viceroy of Sicily. Today there is a castle on the cliff and under its shadow fishing is still carried on, as may be seen in Fig. 6, made from a photograph.

Following on the rather technical description above, the following quotation from Mercadante (one of the Italian authorities referred to above) will bring

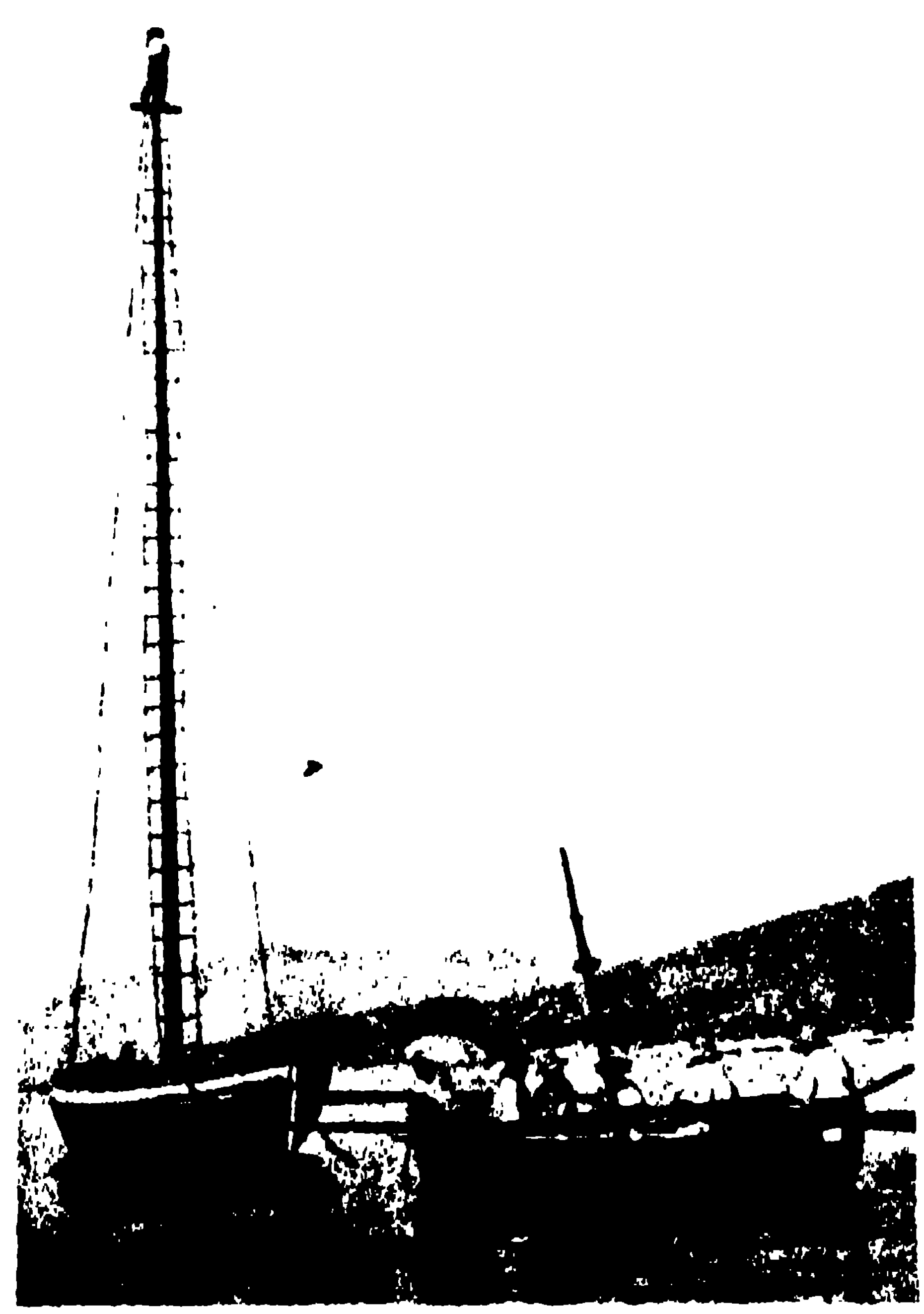


FIG. 7. FISHING IN SHALLOW WATER OFF LOW SHORES IN THE STRAIT. NOTE THE *felucca* OR LOOKOUT BOAT WITH ITS TALL MAST (*antenna*) AND LOOKOUT OR *antennière*. NEARBY IS THE *luntro* OR PURSUIT BOAT WITH ITS SLEEPY FISHERMEN.

the whole scene—especially in its romantic aspect—before the reader. It is dated 1906.

The view, . . . during the sword-fishing season, is a spectacle unique in its kind, which is well worth seeing. There is the long line of fishing boats, each moored to its own buoy, at a right angle to and not far from the coastline (Fig. 5). Squatting in each boat are the fishermen, unmindful of the burning rays of the sun. From time to time, they turn their eyes to the mount from which their lookout scrutinizes and examines the whole extent of the sea which his view includes; then they turn burning glances of pique or envy toward their nearby companions, more fortunate because of a fish having appeared in their section of the sea.

On high, the lookouts, in the midst of the thick green of the trees or vineyards, appear like dolls when viewed from the sea. Now from one, now from another, come cries to direct the fishermen. These, all anxiety, bend over their oars and row with all their strength, obeying the *flière*, who, from his little mast in the boat, directs their movements, inciting them with the words *Tuttu paru, tuttu paru, vò!* (Straight ahead!). While from the lookout come the same cries, accompanied by wavings of his banner.

The fish appears on the surface of the sea, only to disappear and presently to reappear in the waters of another post. The men and boat of this station joyfully take up the chase in their waters. Then follows the slow return to its own post of the unlucky boat deserted by the fish, since it is forbidden to follow the fish into the station of another boat where it has reappeared and to which boat it now belongs.

All these things contribute to the anxiety and agitation, not only of those who take part in the hunt, but of the disinterested spectator who is merely an onlooker and watcher of the fishing.

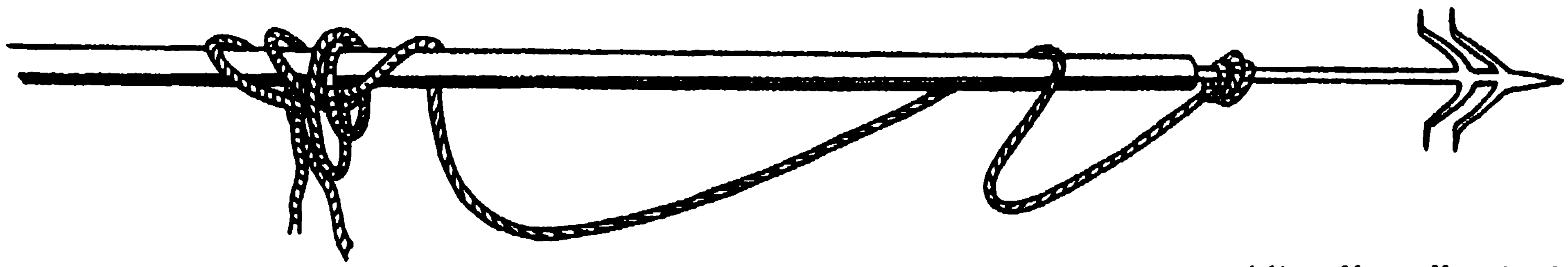
Present-day Fishing off Sicily

Even more off the Sicilian coast than off Scylla, the pursuit of Xiphias is a hunt, since the fish has opportunity to range more widely. This is due to the fact that the shores are somewhat low and the water shallow, and hence the

After Mazzullo, 1906.

FIG. 8. HARPOONING THE PESCE SPADA FROM THE LUNTRO

THE *antennière* HAS LOCATED THE FISH, THE LOOKOUT FROM HIS LITTLE MAST HAS PUT THE *luntro* ONTO THE FISH, AND THE *farière* DRIVES HOME THE TRIDENT.



After Mazzullo, 1906.

FIG. 9. THE DELPHINERA, DRAFFINERA OR TRAFFINERA

THIS IS THE MODERN TRIDENT USED IN TAKING XIPHIAS IN THE STRAIT OF MESSINA. THE WINGLETS ARE HINGED AND ARE SET IN PAIRS AT RIGHT ANGLES. WHEN IN THE FISH'S FLESH THEY OPEN OUT AND FORM TWO DIAMETERS, SECURELY HOLDING THE FISH.

fishing is done farther out. Here and in other posts of the strait where the hills are low or are some distance from the shore, there has been evolved a very ingenious modification of the ordinary method of fishing. There must still be a lookout with an extensive field of vision. This is secured by erecting on a large boat (a *felucca*) a high mast called an *antenna*. This mast (Fig. 7), which is sixty to eighty feet high, is secured by lines reaching from its top to the sides of the vessel, after the fashion of the shrouds in a sailing vessel. Dependent from the top and fastened at the bottom is a rope ladder by which the lookout, or *antennière,* ascends to his platform near the top of the mast.

From his perch at the masthead of the lookout boat, the *antennière* gazes down on the sea as on a mirror. Nearby is his own fishing boat, and in the distance are other lookouts and fishing boats. When all is serene, all is romantic; but even then a four-hour "trick" in the broiling sun, with no fish in sight and with nothing but at best lukewarm water to drink, largely takes away the romance. But when the wind rises accompanied by a swell, and his uneasy perch swings through an arc of 40° or 50°, his position becomes perilous in the extreme. He must hold on "by his eyelids," as the sailors say.

Attending the lookout boat, or *felucca,* are one or more fishing boats generally called *lontro* or *luntro*. Each has four to six men as a crew. When no fish are in sight, these men sit sleepily in the hot sun, while one man (probably the captain) unfurls an umbrella (Fig. 7). However, when the lookout sights a fish, all is activity and the method followed is that described above and indicated in Fig. 8, in which the harpooner is ready to drive his weapon into the *pesce spada*. When he strikes a fish, the harpooner shouts, "Hail, blessed Saint Mark!"

Of special interest is the peculiar harpoon used everywhere in the strait, and called *delphinera* or *draffinera* or *traffinera*. This consists of a wooden shaft about twelve feet long, furnished with a curious steel head. In this the central shaft is continued in a median point or spike, but on either side are two, and sometimes four, winglets. Fig. 9 is made from the colored cover of one of the 1906 brochures on swordfishing in the Strait of Messina. This, unfortunately, does not show that the four winglets are *hinged*. But so they are—this in order that they may lie close to the central shaft and point upward when this harpoon is driven into the flesh of Xiphias. When there are four earlets or winglets, the pair nearer the point of the delphinera are shorter than those higher up. This pair is set at right angles to the other pair and when opened up the points are seen to form two diameters at right angles. When this curious harpoon is driven in the fish and the line tightened, the winglets open out and most securely hold the fish.

Attached to the harpoon head is a line, the *protese,* often six or eight hundred feet long, with which to hold the fish while it tires itself out. Sometimes the

shaft is dragged about by the wounded fish, but generally it becomes detached and is drawn to the boat by a warp. The retrieving of line and fish is generally done by a second boat, while the first returns to the battlefield to hunt for another fish.

Greek Influence in the Messina Fishery

Until the very recent past there survived in the Messina fishing certain reminiscences of a very ancient Greek origin of the method of taking Xiphias. These undoubtedly came about as follows. The Greeks migrated to and settled in Sicily and Southern Italy as early as about 800 B.C. As time went on, their trading colonies grew into cities (Agrigentum, Crotona, Messana, Neapolis, Rhegium, Tarentum, etc.), and this section of Italy was called Magna Graeca. Quite surely they brought with them from the east a knowledge of the fish they called Xiphias, and certainly they hunted him in the Strait of Messina long before the Christian era. Presumably they originated the trident fishing and passed it on to the Romans. This Greek influence is found in certain words and sentences used in the fishing. Of this Brydone wrote in 1773 that:

The Sicilian fishermen (who are absolutely superstitious) have a Greek sentence which they make use of as a charm to bring the swordfish near their boats. This is the only bait they use and they pretend that it is of wonderful efficacy and absolutely obliges him to follow them; but if unfortunately he should overhear them speak a word of Italian, he immediately dashes deep under water and will appear no more.

To-day the swordfishermen have a specialized code of verbal signals by which the lookouts direct their boats. Even until about 1900 (Mazzulo, 1906) these same signals were given in Greek. The idea was that Xiphias was lured by this siren song in Greek (his native tongue, so to speak) and held a spellbound victim for the trident. But should he hear a word of Italian, the spell would be broken and, faster than the harpooner's arm, he would make off, to return no more. To-day, however, the "tongue" has undergone a complete reversal, for now the people of the lower class jokingly say that they speak in Greek so that the fish will *not* understand and hence not run away.

The Perils of the Messina Fishing

Swordfishing or, more properly, swordfish hunting, is such a romantic undertaking and such good sport, demanding much skill and strength, that famous warriors, princes and even sovereigns have come to the Strait of Messina to engage therein. And undoubtedly Xiphias has retaliated hundreds of times by attacking the boats of his persecutors. Indeed, every describer of this fishing who has been consulted so says in general terms. But with one exception, specific accounts are unfortunately lacking.

However, it is related that while Don Juan of Austria was waiting at Messina for the fleet with which a few months later he defeated the Turks at Lepanto (1571), he became so enthusiastic and skillful a harpooner that he killed six swordfish. But one of these, "not very much resigned to die, launched itself against his boat and pierced it from side to side." The prince saved the sword and sent it to his father as a memento of his experience.

BIOLOGY AND HUMAN AFFAIRS

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I

AT the present stage of human history when Europe has been teetering between peace and war, and has finally taken the plunge into the abyss; when Japan is laying waste the land of a peaceful people and millions of innocent lives are being snuffed out; when unemployment in the United States is still wide-spread and industry is staunchly opposed to the punitive, discouraging measures of the Federal Administration and its open-handed spending; when the entire world seems unsteady, uncertain and bewildered about the right course to pursue, it may be desirable to forget economics, armaments and psychology temporarily and to focus our thoughtful attention on man, the animal.

Given man as he is, can we expect a better order of things as a result of his planning and organizing ability? Or has the world always been beset with problems—sometimes great, sometimes small, but always present and always undermining or jeopardizing human security and happiness? Can we expect that order of things where "peace on earth, good will toward men" will be the permanent guiding philosophy in human relations? Or must we learn to accept the point of view that man, by and large, is grasping, selfish, envious of his neighbor's possessions and anxious to achieve power and importance or their equivalent in the form of great wealth? It is desirable to investigate some of these fundamental questions in order to find new light and wisdom in seeking their answer.

To the great majority of human beings the fundamental relationship and affinity of man to the other forms of life in the universe is either unknown, ignored or forgotten. Darwin's theory of organic evolution has been ignored almost entirely except as a concept to be considered briefly in classes in biology, without any relationship to human living, and then to be promptly forgotten. Very few persons are conscious of the inexorable fact that man is endowed at the time of birth with certain potentialities, beyond which he can not go. A favorable environment will help to bring these potentialities to fruition, but the best environment will never endow an individual with qualities he does not possess.

The human being is like an exposed photograph. The picture is there in the negative and can not be altered. That is the contribution of heredity. The type of developer used and the expertness employed will determine the character of the resulting picture. That is the influence of environment. It is therefore erroneous to assume that all men are born equal. They are equal before the law, but they are vastly different in their endowments and potentiality. Some will be leaders, while the great majority will be followers. Some will be scientists, inventors, teachers, engineers, physicians, lawyers, bankers, business men, publicists, statesmen, etc., while the great majority will be artisans of one kind or another, pursuing the more humble occupations of life. That is natural law. It has always been thus from time immemorial, and there is no reason for believing it will ever be otherwise.

The aim of organized society should not be to bring all humans to one level. That is anti-biological. It will not work. Russia tried the experiment and had to

abandon it. Innate differences in human beings must be recognized and developed for the best interests of society. The aim of organized society should be to provide an equal and satisfactory opportunity for every one at birth in order that every individual may attain the maximum development of his potentialities. If this could be achieved, a state approximating Utopia would have been attained. But alas, even this desirable and theoretically feasible state is difficult of actual achievement.

II

The law of nature is for one form of life to live at the expense of another. It is universal throughout the animal kingdom from the lowly amoeba to exalted man. The amoeba surrounds and devours the bacterial cell and other forms of living and lifeless organic matter. The beautiful song-bird which gives so much human satisfaction lives on earthworms and insects, when it can get them. The cat crawls along never so quietly and cautiously to capture the song-bird unawares and to still its pretty song and make its body part of itself. Dogs and cats are generally instinctively unfriendly, although they do not devour each other. The lion, the tiger, the leopard, the wolf, as well as other beasts of prey, live on smaller and weaker animals in their environment. Large fish live on smaller fish; large, predatory birds like the hawk feed on smaller, harmless feathered animals. Everywhere throughout nature, one form of life exists at the expense of another. That is the law of the living universe. He who has scruples about eating living things, animal or vegetable, soon ceases to exist.

Man is the most efficient of all animals in insuring for himself a constant supply of food. He has domesticated animals to furnish him milk and eggs and meat. He has learned to grow various grains to insure a constant supply of breadstuffs and cereals. Now he cultivates fruits and berries, vegetables, sugar-cane and sugar-beets. He has learned to make butter from cream and to preserve food indefinitely by adequate refrigeration, by canning, by drying, by pickling and by various other methods. The revolving seasons of the year do not bring fear and want on the one hand, nor joy and plenty on the other. Through rapid means of transportation coupled with adequate refrigeration fresh foods are now available in the north temperate region at all seasons of the year. And even if these facilities should fail temporarily, canned foods and other preserved foods are available at all times. The specter of starvation has been virtually banished in this country and in other progressive areas of the world.

Man has insured his essential means of sustenance by using his superior brain. But his supremacy must be demonstrated every day of his existence. Eternal vigilance is the price of safety against bacteria and other microorganisms as well as rodents who vie with man for the possession and use of his foods. Milk is pasteurized in order to make it safe for human consumption. Water supplies are filtered and chlorinated so that typhoid fever germs and other intestinal bacteria may be eliminated or rendered innocuous. Most foods are consumed after thorough cooking, partly to make them more digestible and partly to render them free of harmful bacteria, protozoa, worms and other parasites. The world belongs to man because he has demonstrated his superior ability to survive in the conflict with all other living things and for no other reason.

III

In this wonderful world, with its revolving seasons; with the sun, the moon and the stars; with an atmosphere that is not too cold nor too hot for survival, and which contains the precious oxygen so vital to life; with the birds, the trees,

the flowers, the mountains and the seas, the rivers and brooks and all that goes to make the earth beautiful and wonderful, there is probably no other living thing as remarkable as man himself. Man alone can stand off and wonder about the mystery of life and the universe. Man alone can ask himself the question, "Where did life come from and whither does it go when it departs the human or animal frame?" It is man who can write poetry and immortal literature and preserve them to the end of time in spite of dictator conflagrations and other acts of barbarism. It is man who has written great symphonies and lyrical songs and who has created works of art of immeasurable beauty and soul-satisfying quality. It is man who has conquered the forest and jungle, the great vastness of the oceans and the atmosphere and the hazards of swamp, mountain and great distance. It is man who has spanned rivers with beautiful, majestic, lace-like networks of steel and who has burrowed under rivers and through mountains in order that he might pass quickly and safely from one place to another. It is man who has built reservoirs to guard against drought. It is man who has developed the telephone, the radio, the telegraph, the internal combustion engine and the enormous system of paved roads that link every city and hamlet together in a sense of friendly intimacy and nearness.

These are some of the great achievements of man in the control of his environment. Other achievements are equally great. The establishment of the germ theory of disease and knowledge concerning the sources of infection and their modes of transmission have made it possible for man to enjoy healthy living to a degree never realized before. The average life span has been prolonged, and great suffering and loss of precious human lives have been prevented. It has been a remarkable demonstration to show that flies, mosquitoes, fleas and lice may transmit serious and fatal diseases to man. It has been a great achievement to discover vitamins and to demonstrate their importance and the importance of minerals in human and animal nutrition. Modern science, which must still be regarded as being only in the infant stage of its development, has transformed the universe for man and made him master of its temporal destiny to a greater degree than ever before. Science has made it possible for man to save human life, prolong its usefulness and make it more secure. The abuse of science has brought in its wake sorrow and misery, war and destruction, and terror and anguish beyond human credulity.

IV

It is this conflict between the dual nature of man that merits further analysis. It is as though man were capable of living two lives—one devoted to enhancing his welfare, the other designed to injure, to exploit and to destroy. One is a realization of his dream life, where all men are noble and worthy of assistance; the other, the realistic interpretation of life, that man is an animal and that the fittest and strongest must survive at the expense of the weak. Probably there is no species of life on the face of the earth other than man in which the dream life and the realistic life, the benevolent life and the cruel life, are practised simultaneously with such a high degree of perfection. Not only is one nation or group of nations arrayed against another, but the suspicions, antagonisms and hatreds between races, between different religious sects, between people of different color are too well known to require further elucidation. This is true even in the twentieth century, when time and space have been nullified to a large degree and when education and enlightenment are supposedly more wide-spread than ever. Even in the United States, the melting pot of the entire world and a country

of boundless resources and a very high standard of living, the fusion of the various elements can hardly be said to have occurred successfully.

True, there are numerous exceptions. There are many (numerically but not proportionately) who have risen above class and creed and color and who live harmoniously and happily with the representatives of other races, nationalities and religions. But the majority simply tolerate those who are different and consequently are easily susceptible to propaganda or education designed to foment trouble. The campaign against the Jews in Germany in recent years has had its repercussions in every quarter of the world. Even the United States and Great Britain have not been uninfluenced by it. The difficulty of placing young college men of unacceptable nationality, religion and color in industry and the professions is too well known by those who have tried to do so. It is questionable whether these innate antagonisms can be extirpated by either force or education, for they would seem to have a biological basis. Those rare, high-minded individuals who have risen above class, nationality, creed and color must be different. They are endowed at birth with the elements that make for magnanimity, for charity, for tolerance, for affection to one's fellow men. But even in these individuals, the antagonism toward others is often not entirely eliminated, but simply modified in greater or lesser degree.

History is replete with instances of the noble dream life of men on the one hand and the cruel, remorseless, realistic life on the other. No one group of people, no one creed, nationality or color has a monopoly on one over the other. Jesus of Nazareth is doubtless the outstanding character in Western civilization who preached and lived a life of love toward his fellow men. He dreamed of a human society governed on the basis of love and ethical behavior. But he was persecuted by his contemporaries as a dangerous individual and finally crucified. For almost two thousand years his spirit has moved among men, urging them onward to the dream life he envisioned, but alas, we seem just as far removed from its attainment, in spite of millions of sermons urging us onward, as we were when He was alive. Other great spirits have motivated the Moslems, Hindus and Oriental peoples to similar heights of human behavior, but always with the same frustration.

It may be argued that the world would be poorer spiritually and in a worse state physically without these great religious leaders. That may or may not be so. We shall never know. The fact is that we can not divorce religion in its ethical and spiritual aspects from our daily lives, for that kind of religion is necessary for mental and physical health and that kind of religion is the only means available to man to bring the dream life into organized society.

Those who remember Woodrow Wilson's heroic measures to keep this nation out of war, and to whom the dream life of a better world is still a stirring challenge, will thrill at the recollection of such phrases as "A man may be too proud to fight" and "Peace without victory." Later, when he was forced to lead this nation into war against the Central Powers it was "To make the world safe for democracy." True, he was determined to use "force without stint or limit" to achieve his end, but his aim was not territorial or material aggrandizement. His aim was to release the German people from the fetters of an imperialism that bound them and made them helpless and prevented them from living at peace and on friendly terms with their fellow men. Military victory he achieved, but alas, at the very moment when his dream life was about to be realized, he was thwarted at home and abroad and a realistic conception of life was substituted at the Peace Conference. The "heart of humanity beats under common jackets," he said, but the

brains that govern and rule humanity still function in the bodies of realists adorned in morning coats.

Rarely is anything entirely white or black in human relations. Usually it is a compound of both, with varying degrees of blackness and whiteness. Life is replete with instances of noble behavior and with efforts to grasp and hold the vision of the dream life even for a brief, fleeting moment. The horrors, barbarities and cruelties of the World War were tempered by innumerable acts of courage and heroism, by assistance to dying or injured comrades, by self-sacrifice even in order to salvage or protect something beautiful and holy or somebody who meant more than life itself. The psychology of the time was self-sacrifice for a cause, for an ideal more precious and beautiful than mere mundane existence. It was an ideal that appealed to youth. That was the dream life come true. The end of the war brought in its wake disillusionment and frustration. The realistic philosophy of life was once more to the fore.

In the field of public health the opportunities to live the dream life are possibly greater and more frequent than in any other field of human endeavor. Unfortunately, public health work is usually not associated with spectacular displays which arrest popular attention and stimulate human emotions. The physician who relieves aches and pains has contact with human beings who honor and adore him and who tell the world of his greatness. The surgeon who explores the recesses of the body and cheats death of its victim is recognized as a human savior and is universally proclaimed. But the health officer or engineer who purifies a polluted water supply capable of dealing death and destruction to thousands, or who builds sewers and plumbing systems, or who sanitates and pasteurizes the city milk supply, or who insures the safety of the food supply, or who drains swamps and controls mosquito life, or who purifies the atmosphere in the home, in the factory and in the community or who does any one of a number of other things which make for human health and comfort, he remains unnoticed and unsung. The effectiveness of his efforts is reflected merely in lower community death rates and in greater longevity. His contribution is to the entire community and not to any specific individual, and hence he is not acclaimed as a great public benefactor except perhaps posthumously and on rare occasions when he has completed twenty-five or fifty years of continuous, poorly remunerated service.

The better qualities resident in man are always stimulated during periods of emergency. Witness the thrilling rescues at sea during storms and at great hazard to those happy to be chosen for the task. Every human heart thrills to the rescue and relief work performed during flood, fire, hurricane, earthquake and other catastrophes. It is a privilege and pleasure to give on such occasions if one is unable to serve. Witness, too, the constant support of the needy, the care of the sick poor, the protection of the aged and the feeble, the veneration of womanhood and motherhood, the lending of a helping hand or a kind word in all the daily walks of life. During the recent depression, when millions were unemployed, no one in the United States was allowed to starve or to freeze to death. These are all instances of the nobility inherent in all humans, of the realization of the dream life on earth. There are few, indeed, who are so calloused and disillusioned that they do not respond to the vision of an ideal society, where men will love one another, where war will be banished forever, where want and misery have disappeared, where all will be equal and live in happiness. The sermon, the play, the lecture, the article that portrays this ideal state stimulates more joy in the human breast than any other form of intellectual message. Man has a yearning for Utopia and in his dream life will ever strive to attain it.

He may be frustrated and disillusioned again and again, but he will never live long enough to cease to thrill to its inspiring stimulus. We are all like children, and we carry our love for fairy-tales and miracles, in one form or another, down to the end of our days.

The realistic aspect of life in human society is, alas, only too apparent on every side. The struggle for supremacy among nations and among individuals is one of the saddest of human spectacles. In 1914, Germany practically controlled the world, but she was not satisfied until she possessed and dominated it as well. Her ships traveled to the four corners of the earth. Her industries commanded the greatest respect and admiration everywhere. Her art, music, literature and culture were renowned. Her universities and research laboratories were the mecca of students and scientists and the envy of everybody. She was rich. She was powerful. But something innate in her protoplasmic composition, something biological, made her want more.

Within other nations the picture is essentially similar. Wealth is poorly distributed. Some persons are fabulously rich, while others are incredibly poor. Some are greedy and avaricious and take more than their just share of this world's goods. Those men who received fabulous bonuses in 1929 and 1930, sometimes as large as $1,500,000 and $1,600,000 in addition to a handsome monthly salary, were taking more than they deserved. Such men, it was said, were supermen. They could get business for their companies where ordinary individuals could not. The depression years exposed that fallacious theory. The supermen became mere ordinary individuals. The machinery in their industries did not function more actively than in others. They could not manufacture orders when orders were not available.

The publication this year of the ridiculously exorbitant salaries paid to the producers, actors and other appendages in the moving picture industry in the United States indicates the existence of a racket which will have its day of reckoning. Can the relative contribution to the welfare of society of professors, research scientists and professional workers generally be determined by their annual earnings in comparison to those obtained by the moving picture czars and their appendages and by Big Business generally? Or does one's nearness to the bulging money bags determine in a large measure how much one gets?

Another instance of realistic living is found in the lives of the racketeers in the United States. They are the modern version of the Jesse James boys, who looted and intimidated and killed to get something for nothing. The bootlegger was a disgrace to our finer traditions during prohibition days. The industrial racketeer has terrorized thousands, killed when necessary, extorted toll from both labor union and employer. There have been poultry racketeers, laundry racketeers, bakery racketeers, fur racketeers, clothing racketeers, etc., *ad infinitum.* Always it was easier and safer to pay tribute and to keep quiet than to do something about it. It was only when community decency became outraged at this open rape, and when by good fortune those in political power happened to be on the side of decency, that some of these rackets and racketeers have been brought to term. The fact that racketeering is a recurring disease leads one to suspect that it is reasonably wide-spread, that it never dies out altogether, and that it becomes active once more in a given community when the conditions are favorable again.

One would suppose that the realistic life would at least be absent in the field of religion, but that this is not so is apparent to the informed. When a professional traveler returning from Mexico reports that in a town of less than 10,000 inhabitants there were so many churches of one denomination that an individual could go to a different one

every day in the year and not exhaust the supply, one wonders whether the church is more interested in serving its adherents or promoting its own physical well-being, especially as poverty and ignorance are wide-spread among the people. The same traveler reported that the ornaments and decorations in the cathedral of Mexico City represented fabulous wealth. One must not be condemned as being anti-religious or anti-church to give expression to such obvious materialism at the expense of human welfare. If revolt to such injustice has occurred in other sections of the world where such conditions have been duplicated, it is at least understandable.

Witness also the rabble-rousing behavior of a radio priest. Using innuendo, spreading misinformation or half-truths as the whole truth, asking suggestive questions instead of making definite statements, this self-appointed guardian of human liberty and champion of the common man flays communism and whips up the emotions of his listeners against innocent people and sets up bogies to serve as smoke screens for the thing he desires earnestly to protect. Why does the radio-priest flay communism so methodically? Is there danger of communism here? Is he afraid his church will be discredited here as elsewhere? There is no need for this fear, if the church is ethical, if it is not too grasping, and if it caters to the physical as well as the spiritual well-being of its people. If we can not expect to find the noble life among those who wear the cloth of the church, where shall we look for it? It is of course true and well known that all religions abound with noble selfless leaders. They add beauty and love and aspiration to the daily lives of millions.

Even the fields of public health and education are not free of the poisonous virus of the realistic life. Teachers and matrons in the public school system have in some instances been appointed only or largely from one nationality and religion. School physicians employed on a part-time basis have not visited the schools under their supervision for years, but have had an understanding with the school principals to call only if a card were exposed in the window. Public health nurses in some instances have been appointed without adequate preparation and training and have functioned without supervision. Tuberculosis hospitals have served as free board and lodging institutions to large numbers of individuals, presumably tuberculous, who would enter in the fall, with the approach of cold weather, and depart in the spring when the weather was milder. The appointment of untrained sanitary inspectors in health departments from the politically deserving has occurred with astonishing frequency. Experience proves that public health and public education are sometimes used and extended as a means of distributing the wealth more equably and as a means of giving jobs to the "deserving."

V

The foregoing facts portray very clearly the constant struggle between the effort to achieve the dream life in organized society and the realistic life that counteracts, retards and nullifies it. For two thousand years of recorded time, and more, this struggle between good and evil, between tolerance and intolerance, between understanding and lack of understanding, between love and hate, between charity and greed has been going on. Education, religious instruction, science, engineering, economics, sociology, psychology have not succeeded in bringing about a solution. The reason, perfectly clear from a biological standpoint, is that fundamentally man has not changed. We have placed our faith first in one system and then in another and have always experienced failure. No system which man can devise can take the place of integrity, unselfishness, devotion to duty and the overpowering desire to render justice to all

regardless of race, creed, color or economic circumstances. It is certainly easier to modify systems, to replace democracy with authoritarianism, for example, but always the basic human elements involved remain the same. There may be a change of human objective, from the mere accumulation of wealth to a struggle for political power and position, but the evils involved in living the realistic life remain unaltered.

Efforts to transform man himself have failed because man is what he is. Education and environment can only bring out what he already possesses by heredity. They can not alter the basic pattern with which he is endowed. One environment may favor the appearance of certain characteristics, good or evil, but the others are there ready to come to the surface at the slightest opportunity. Perhaps some day the biologist, aided by the organic chemist, the biophysicist and the biochemist may learn how to control and modify the hereditary pattern or to alter the adult individual and in that way develop a new race of men capable of living the dream life. But until that day arrives, if it ever does, the world will go on more or less in the same way. History teaches us, much as we regret to accept it, that it can not be otherwise.

Is there no hope, then, for a better human society, where war and famine will be banished, where hate will be kept in abeyance and where human beings can live happily with reasonable security and with the knowledge that they can bring up their children with a reasonable approximation to equal opportunity? I firmly believe that such a human society is possible. The means of achieving it, though simple to record, are tremendously difficult to attain. For to achieve it, we must recognize and admit that human beings differ in their heredity and hence in their potentialities. Some will have to be the workers of the world, while others will be the leaders, the inventors, the more significant contributors. Each must be rewarded in accord with his significance and his contribution. There must not be, since there can not be, a dead-level society.

Another difference must also be recognized, namely, that some men are more just than others; some are more honest; some are more scrupulous; some are more tolerant and charitable and selfless. In short, we must recognize the fact that some men are capable of leading and directing the dream life better than others. If a community can voluntarily select such men as leaders—and it is difficult to visualize how a democracy like ours can do that—then human society will approach the ideal state as closely as it can ever hope to do. This does not mean that human society must be governed by visionaries, by men who lack force and personality. There are men who can live and plan and direct the dream life who also have force and personality. When we achieve this goal, we shall be putting our faith in men. The system will not matter. Their aim will be service to their fellow men without the evils that frequently go with power. But in order to keep such men in power, in order to make it possible for them to achieve and maintain the dream life, it will be necessary to implement them with adequate force capable of keeping the apostles of the realistic life in check.

Until that distant day arrives, if it ever does, we must go on wrestling with the same problems of organized human society, in greater or lesser degree, that have challenged thinking man down through the ages. Here and there, in isolated communities all over the world, circumstances will thrust benevolent and wise leaders into positions of power. And in these communities, the world will see the closest approximation to the attainment of the dream life for the brief period during which these unusual circumstances exist.

BEES RAISE QUESTIONS

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In many ways, the behavior of bees suggests our own ways. Old beekeepers always attribute to their pets the will, the motives, the emotions that they recognize in themselves. Bee-keepers speak of bees in the language of human conduct.

In comparing bees and men certain factors should be borne in mind. From the evolutionary standpoint, we are of course very distantly related to bees, but our common ancestry is not nearer than the segmented worms or perhaps the Cambrian Eurypterids which lived 100 or perhaps 1,000 million years ago. A common origin of our protoplasm explains perhaps the similarities between bees and men in their cruder chemical and physical structure, and even in the muscles, nerves, skin, digestive tracts and body fluids. Both man and bees are made up of proteins, fats and carbohydrates; our active tissues are all protein in nature; we store excess food in our bodies as fat (insects are very oily); we consume carbohydrates and oxidize them for release of energy. We all get our protein and carbohydrate from the plant world, and give it back to the plants during life, as water, carbon dioxide and nitrogenous wastes, and at death our bodies return to dust. There is little reason to think that our common ancestor was capable of experiencing any of the appetites or emotions that we know in ourselves, although Jennings does assert that if the amoeba could be seen and known as we see and know dogs, we should attribute to the lowest animal organism known to science "states of pleasure and pain, of hunger, of desire, and the like, on precisely the same basis as we attribute these things to the dog."

Man and the honey-bee are, however, so profoundly different in most respects that we might almost regard them as inhabitants of different planets. Where the two creatures resemble one another, we often seek some other explanation than that of common ancestry. Usually it is due to adjustment on the part of the bee to the same world as that in which we live and to which we are adjusted. For life is adjustment, and any serious lack of adjustment quickly leads to death.

Our common ancestor was without any means for breathing air or for motion on land or for resistance to the desiccating effect of dry air, or for terrestrial hearing or smelling or seeing. It follows therefore that the adjustments of men and bees to terrestrial life have been achieved quite independently of each other.

As to breathing, we draw air into our lungs, there load the blood with oxygen and then pump it throughout the body to carry oxygen to the tissues. The insect has a system of fine air tubes whereby the air itself is carried to every part of the body. For motion the bee has six limbs to our four, and surpasses us completely by the possession of four wings. But her limbs so closely resemble ours—made up of two long pieces and a set of small pieces at the foot—that we not only speak of the legs and the feet of the bee, but we call the parts femur, tibia and tarsus. Obviously this resemblance is strictly superficial. It is not due to common ancestry, but to the mechanical nature of the world we inhabit.

The skeleton of the bee consists entirely of her hard outer shell, which serves in place of bones. This shell also

serves to prevent desiccation. Our bones are inside us, and consequently we must have a special waterproof skin to keep us from drying up. The powerful muscles of the bee are attached to prongs and bars of the shell, which often project far into the insect's body. That this method is adequate is proven by the legs of the grasshopper and the wonderful flight of many higher insects. Once I saw a worker bee grasp a dead bee by her legs and fly up as high as the house and over a neighbor's lot before dropping her load. The muscles of the bee are "striped" exactly as are the voluntary muscles of the vertebrates. No worms have such muscles.

The eye of the bee is too complex to describe in detail, but it depends upon the lens-shaped bodies of dense refractive material which focus the rays of light. Of course, this is an adjustment to the nature of light-waves in relation to solid bodies. The food of the bee consists of nectar, or honey, and pollen, the latter being the richest bit of protein that plants produce. Why has man never found a way of eating pollen? I have tried it but without success; it didn't taste good. The nectar of flowers is mostly a very thin solution of cane sugar which the bee sucks up and swallows into a special pouch called the crop. The crop connects with the throat of the bee, as our lungs connect with our esophagus. In the crop or later, the cane sugar is partly inverted or predigested, becoming dextrose and levulose. This is exactly the effect of human digestion upon cane sugar.

In the hive, the bee regurgitates the thin solution of sugar which is received and placed in a cell of the honeycomb by a house servant. The water is evaporated by currents of air, set up by fanning by the wings of the bees. During this process the honey is tongued and tested by another class of workers. When a cell is full of sufficiently concentrated honey, it is capped over with wax and sealed. Now this honey, or nectar, serves as the carbohydrate ration for the bee, but pure cane sugar syrup does just as well. Consequently we may take away from the bees all the honey they make and feed them during the winter on a sugar syrup. At this point their digestions are very much like our own, but the inversion of cane sugar in both cases is due primarily to the nature of the sugar molecules, not to the relation between bees and men. Nor should it be assumed that all protoplasms can use the sugars interchangeably. Many bacteria can use but one or a few kinds of sugar and will absolutely starve if given only some other kinds.

Well-finished honey is about 20 per cent. water. A colony of bees will consume from 20 to 40 pounds of honey during the winter months when they can not leave their hives. For each pound of honey consumed, at least three quarters of a pound of water and one half a pound of carbon dioxide will be exhaled by the bees. That is, a hive of bees generates seven to ten quarts of water during the winter, all of which must be expelled from the hive. It is a delicate matter to get enough ventilation to eliminate the moisture, and yet not take in enough cold air to freeze the bees. Sometimes the water does condense on the inside walls and top of the hive. If it drips down and freezes at the entrance to the hive, completely stopping the entrance, the colony will quickly die for lack of air, asphyxiated by its own carbon dioxide.

The production of carbon dioxide by bees, as by other animals, increases with the temperature and the activity of the animals. When cold and at rest, bees produce but little carbon dioxide and need but little air. One cold evening in early winter, I moved two hives, disturbing the bees and setting them in motion. For some hours afterward it was neces-

sary for them to keep up a vigorous fanning with their wings at the entrance of the hive in order to expel the vitiated air and to draw in enough fresh, cool air. On moving one hundred hives of bees one autumn, we packed the entrances tight with soft snow in order to keep the bees from emerging. But the bees directed a current of warm air against the snow and melted holes through it in from three to five minutes.

In winter, or at any time of rest, the bees cluster together in a solid mass. Those at the center are constantly working out to the surface of the mass, while those at the surface are working in. A neighbor undertaking to kill a small colony by freezing, uncovered the hive, spread the combs apart, and left them overnight. The next morning, with the temperature at 10° F., all the bees were still alive. By remaining in a compact mass and continually exchanging places they were kept warm by their own body heat (combustion of sugars). The healthy cluster maintains a temperature of 57° or above.

Bees can not void their excrement except when flying; at least it is believed they do not. During the winter their abdomens become greatly distended with waste matter. If their stores are of inferior honey, this condition will be intensified and may prove fatal. If wintered out of doors, bees usually find days in January or February when they can fly out. Hence, wintering out of doors with sufficient protection is better than wintering in a cold cellar, for in the latter case so-called cleansing flights are impossible. Since bees can live all winter with only honey, *i.e.*, water and carbohydrate for food, during these periods they use protein sparingly in their life processes, and they must be in a state of extreme protein starvation when spring comes. There are in honey, usually, a few grains of pollen, and some pollen is commonly stored in the hive in the cells separate from the honey. Perhaps from these sources bees get a sufficient protein ration, but I think they eat only honey in winter.

The personnel of a colony of bees consists of three castes or classes: Drones, workers and queen.

Drones are male bees. They are much larger than the workers, and are present in a hive by tens or hundreds. The drones can not gather honey or pollen and can not even feed themselves, but are fed by the workers. They buzz very viciously but have no sting. Their sole contribution to a colony of bees is to mate with the queen, and since a queen mates but once in her life, very few drones ever mate. Drones are reared from June into summer. In September the workers drive them out from the hive and prevent their return. So they starve to death or die of cold.

Drones are the product of unfertilized eggs laid normally in the larger cells of the comb. All drones, therefore, are fatherless, though they have grandfathers and stepfathers, because queens and workers develop from fertilized eggs, and have a male parent. And a drone which mates with a queen will be the male parent of hundreds of workers and a dozen or more queens.

Beekeepers always think of drones as lazy, happy-go-lucky louts, with nothing to do but eat, sleep and buzz about on sunny days, waiting for an occasion for a mating. But for the drone, the mating is a serious matter, for the act is fatal. The queen returns to the hive with the end of the abdomen of the male torn off and hanging to her.

There are from 20,000 to 50,000 (some say 80,000) workers in a strong colony. The worker is an unsexed female, with only rudimentary ovaries, but in a queenless colony one or more of the workers may acquire the capacity to lay eggs. Probably this condition is brought about by the excessive feeding of selected

young bees. Such "laying workers" never leave the hive and never mate. Hence they never lay fertilized eggs; their eggs are fatherless and hatch out only drone bees or males. Such a colony soon dies out, since no new workers can be raised and the life of a busy worker in summer is only five or six weeks. Workers hatched late in autumn live over winter, and do a few weeks' work in spring. To get rid of laying workers, one has only to shake all the bees out of the hive in a grassy place, a hundred or more feet from the original position of the hive; the regular workers will easily find their way back to the old stand; the laying workers, never having been out of the hive, can not get back and will perish. Then the helpless, eggless colony will accept a new queen, if one is offered to it.

Workers alone have mouths for collecting nectar and the honey-carrying crop. They also have combs on their front legs especially suitable for combing pollen off their bodies. The second pair of legs has a notch through which the first legs can be pulled, to gather up the pollen; and the hindmost legs have each a little basket in which the pollen is placed and carried home. Workers differ greatly in their use of this natural equipment. Some return home all dusty with pollen, and let their sisters clean them up. Others enter as neat as a pin, with huge sacks of pollen on their legs.

Last summer a loaded worker entered an observation hive and presently walked along one side of the comb, then went over to the other side, rambled about over and through and under a cluster of bees, looking into various cells here and there and, finally, after several minutes, settled on a place to unload. She put her hinder legs deep into a cell, and remained for about a minute; then she pulled them out, leaving her two lumps of pollen loose in the cell. Immediately, another worker went in head first and remained for about a minute. When she came out, the pollen was tightly and smoothly packed in the bottom of the cell. The bee which lost the time in deciding on a place for depositing her pollen was typical, for most bees seem always to be just milling around aimlessly over the comb. Do not send the sluggard to the busy little bee to learn a lesson in efficiency.

Observers remark the same characteristic when the bees are building their marvelous comb. They run about without any semblance of order or continuity of work. A bee bites at the comb here, sticks on a bit of wax there, and runs on while others follow. But meanwhile the marvelous comb grows up before our eyes! The wax is secreted in scale-like pieces on the under side of the abdomen of the workers. To produce the wax they eat vast amounts of honey and hang in characteristic clusters over night. The wax appears in a few hours. Bees consume about twelve pounds of honey to make one pound of wax, but one pound of wax will build enough comb to contain sixteen pounds of honey. The cell of the comb is not only hexagonal—a response to the nature of the space in which we live—but its axis slopes upward, so the honey will not drip out. There is, therefore, a very definite right side up for honeycombs.

There are three sizes of honeycomb cells. Most of the cells are almost exactly one fifth inch in diameter. As long as the queen lays eggs in the cells as fast as they are ready, this size cell is made. If the workers get ahead of the queen, they build larger cells one fourth inch across. For storage of honey, even larger cells may be made. But all this variety is produced in an apparently disorderly, helter-skelter manner by a host of workers, running about over the comb. We have absolutely no conception of how a precise piece of work can be turned out in this way. Nor can we believe that

the method is economical or efficient. Apparently it succeeds merely by dumb persistence—by force of numbers and in defiance of time.

The workers are custodians of the hives; it is they who fly out and sting the intruder. But the different varieties of bees differ greatly in irritability. The gold-banded Italians sting only after rough handling, but a black bee will probably sting you if you simply stand within five feet of her doorway. This reaction is changed by puffing smoke into the hive or upon the bees. Certain it is that smoke induces the bees to rush to the combs and gorge themselves with honey without stopping to sting the intruder. After smoking the bees one can open the hive, lift out the combs one by one, and inspect them minutely. Sometimes not one bee will attempt to sting; at other times, however, a half dozen will leap on one's hand at once and sting with great energy. Why the calming influence of smoke?

Animals and plants respond to natural stimuli in a manner that has proven, in the last million years of experience, to be useful and profitable. A new and strange stimulus will call forth one or another of the reaction patterns that have been established by age-long experience. Is smoke a new experience, and the reaction fortuitous, or is it a very old stimulus with an adaptive reaction? Since bees have lived for ages in hollow trees, the smell of smoke may indicate to them that their tree is on fire and that the colony should move. So the bees load up with honey and get ready. It is probably possible so to smoke a hive that the workers will leave it, taking their queen along, but usually the queen simply hides among the bees or in some corner of the hive. This hiding of the queen is doubtless a reaction to the stimulus caused by opening the hive. In all the pre-human period bee hives have never been opened up and the combs removed except by predatory animals. And the combs were never put back in as I do it until the invention of the movable frame in 1852. Under such conditions the preservation of the colony depended upon the queen being hidden among the mass of the bees, or tucked away in some deep crevice. Then when the marauder had gone, she could come out and join the remnant of her family to reestablish a home in the same or another hole in the tree.

So when I smoke my bees, and proceed to tear open their hive, I turn loose two ancient behavior patterns—the behavior suited to a burning tree and that suited to an attacking animal. For the first, the bees fill up with honey and do not sting; for the second, they sting violently and hide their queen. The business of the beekeeper is to keep enough smoke in the air to hold the insects to the burnt-tree type of reaction. Even so, why the difference in irritability of the several varieties of bees?

The ability of bees to make long journeys—two to four miles—and return unerringly to their own hive is remarkable. The feat becomes more interesting when we see the bee yard containing 50 to 100 hives, all made as nearly alike as modern machinery and paint can make them, and packed so closely that there is just room for the beekeeper to pass between them. But interest culminates when we learn that this skill is the result of careful training. A young bee first emerging from the hive suns herself on the front porch. Later she flies out a foot or two and buzzes about facing the hive. Then she goes farther and farther, still facing the hive—say to ten or fifteen feet. Finally she makes a real collecting trip.

Last summer I placed a comb of bees in an observation hive, fastened them in, placed them in the cellar to cool off. They settled down at once. Twenty-four hours later I found they were humming

in a tone that indicates mild excitation. (One can tell what a bee is likely to do next by the tone of her humming, just about as well as you can predict the next act of a dog or a person by the tone of his voice.) I took my bees out to a new location and opened the little doorway. It was six P.M., just growing dusk. In a few minutes one bee found the open door. She crawled out, made sure of her freedom, and then stood by the door and buzzed till you couldn't see her wings. Soon another came, and she buzzed too. Then they all made for the door and poured out in a stream, mostly taking wing at once. For several minutes they made quite a swarm within 3 or 4 feet of the little hive, milling about in the air, all facing the hive. Then they spread out farther and farther, to 100 feet or more. I thought they must all be gone. But while I thought it, the crowd gathered again by the door, and all poured in as eagerly as they came out before. In a trice all were in and quiet. Had they been studying the location? Ordinarily, when collecting, they run out of the hive and take wing without a look behind; and returning, swoop out of mid-air directly into the doorway.

When it is necessary to move a colony, one should place a board or net in front of the hive in its new location, so the bees will be compelled to take notice as they come out. The obstruction can be removed after a day or two. There is no doubt that bees can learn to find a certain location, both for their home and for their collecting grounds. A good collecting ground is revisited until its resources are exhausted. Then a new place is sought and similarly worked. Ability to do this is essential to the life of the bee.

I do not see in this any general ability to learn. It is only an adaptation to the peculiar life of bees—gathering nectar from the successive fields of flowers from season to season—and the change of abode when swarming. It does not indicate any ability to learn in any other realm of knowledge.

When bees are much agitated by a disturbance in the hive or by the excitement of stealing made-up honey from whatever source ("robbing"), the bees do not usually settle down until nightfall; they have to sleep it off. The length of time for relaxation depends on the intensity of the stimulus. So it is with a person. When he is greatly excited, he gets a large dose of adrenalin poured into his blood from those little glands in his back. And he simply can not settle down until that disturbing hormone is oxidized or eliminated or sent back to its place. Ritter suggests that the human organization is unified by hormones. Does the bee have hormones? Does a puff of smoke let loose in her body fluids some guiding substances from some hidden gland? And when I open the hive, do I stir up some other hormone, which keeps Miss Bee literally on pins and needles until the hormone works itself out?

Speaking of robbing, whenever bees find a chance to gather real honey, ready made, they go for it and carry it away with the utmost haste and energy. They often tear a comb to pieces, a thing they never do in their own hives. They fight one another while gathering the loot. They are unusually irritable and liable to sting. Once about noon I left a lot of combs, wet with honey, exposed in my shed. On getting home at five o'clock, I found the air full of bees buzzing around the shed and the shed crowded with bees. A neighbor down the street called my attention to the great numbers of bees buzzing around his house, my bees stirred up by the experience of robbing. Were I a Maeterlinck, I could describe them as exhibiting all the passions of a madhouse or an army. With nightfall, the bees mostly came home. I put the exposed combs under cover by candle light, and next day all was quiet.

Bees sting in different ways at differ-

ent times. If one alights quietly on one's face or hand, she means no harm, and soon flies away. If she gets into one's hair by accident, she hurries down and stings. Why? because among the hairs she feels caught; the reaction is to injure and drive away the enemy. If she alights on one's arm and one's sleeve presses down on her, she stings. A drop of ammonia cures it. If her hive is disturbed she comes out with a shrill whistle of the wings, and the intruder is in for it. She alights on his glove, bends down her abdomen and gives a thrust. It misses its goal in the soft fuzz of the gloves. She thrusts again, with a violent contortion,—she misses. Again she thrusts, with a violence that nearly bends her double, and draws her abdomen into a sphere. One is obliged to think of it as an expression of baffled rage and savage bitterness. She looks and behaves like a veritable little fury.

The queen fulfils the Christian admonition that he who would be greatest must be servant to all. (That is the only Christian virtue about bees.) She has absolutely no freedom of action whatever. She can not feed herself, but is fed by her daughters. When she lays too many eggs, the workers withhold food and she lays fewer. If she lays too few, they feed her up. So do beekeepers. If that doesn't bring results or if she lays only unfertilized drone eggs, she is carried out and killed, and a new queen is raised. If she lays eggs in small wax cells, and she is young, she lays fertilized female eggs; if the cell is a large one, she lays unfertilized drone eggs. It seems to be simply a matter of the size of the cell. When the bees are moved to swarm out and leave the hive to start a new colony, the queen goes along with them. If she doesn't go, a guard of workers goes in and gets her. Two summers ago a swarm came out of one of my hives. I caught the queen with difficulty and awkwardness, put her in a cage after much fingering, and gave her and her flock a new hive. Next morning I found her lying dead in front of the hive, with a few bees crawling over her. Authorities tell me I handled her too much; she got a strange smell and the workers killed her.

When a hive is opened on a *rainy day* and rain falls into the hive, the workers are likely to kill the queen. These are reactions for which it is not easy to see an explanation. Once a colony was left queenless by such madness and without hope of ever getting a queen. Left to themselves they would have died out. But they were given the makings of a new queen, which they accepted, and raised a queen and produced 15 pounds of good honey.

Queens and workers come from exactly the same kind of eggs. Queens are raised in very large *cells*, as big as the end of one's little finger, and are fed as larvae upon very rich food called royal jelly. If one takes a young worker out of her cell and places her in a big cell with a bit of royal jelly, the bees will go and make a queen of her. Or, if the queen is removed, the bees will make several queens from the recently laid eggs. When, in 16 days, those new queens are hatching there are exciting times.

A queen emerges from her cell with a number of complete behavior patterns. One day a worker came by just as a queen emerged. She jumped on the worker and was about to give the death blow with her powerful sting when she suddenly stopped and got off. My informant remarked that "she discovered her mistake." Did she? Soon she met a newly hatched queen. Again she leaped on and this time she plunged her sting into the abdomen of her victim between the plates of armor, and the victim curled up and died.

After killing all her immediate rivals, the young queen lives quietly for a day or so, and then goes out on her mating flight. A few workers go with her. They fly up into the air and are gone

a few hours in the middle of the day. She meets the drone in flight and receives into a little sac enough sperm cells to supply her egg-laying for two, three, four or even five years—200,000 to 1,000,000 male sperms. She returns to the hive with a high degree of certainty. Whether she finds her own way back or is guided by her more experienced attendants we can not say. Having returned, she is groomed by her maids, and in two or three days more begins her career of egg-laying. *On occasion a vigorous young queen can lay 2,500 eggs a day, more than twice her own weight!*

For various reasons we often want to give a new queen to a colony—a queen of our own selection, which is quite possible if done correctly. First we must remove the present queen and be sure that no laying worker is at hand. It is well to wait three or four days until the bees have themselves built queen cells and begun to raise new queens. Then destroy all these beginnings, and the colony is hopelessly queenless. There are many ways of introducing new queens. Of course, the situation is absolutely new and strange in the experience of bees. They have no behavior pattern for such a situation. It can only call out some kind of behavior that has been developed for some other circumstances.

Sometimes in adding a new queen to a queenless colony this colony is joined with another. Now there are only two natural situations where a large number of bees enter a colony: First, where a swarm settles in a hole that is already occupied; in this case there is a strange queen as well as strange bees—hence some of the behavior towards strange queens. And, secondly, where the strangers come in to rob and carry off honey. In either case, the rightful owners do all in their power to drive off and kill the invaders. This, then, is the natural reaction when two colonies are united. Last summer I put a small group with a bigger one, and next day the ground in front of the hive was littered with dead bees. Apparently every stranger was killed. To obviate this difficulty, some beekeepers turn in a quart or two of strange bees into the hive and then sprinkle in a quart or so of water. The water changes the type of reaction. One old man tells me: "Oh, no trouble at all. If they get to fighting, just get a spoonful of flour and dust it into the hive all over the bees. Then they get so busy cleaning each other off that they forget all about their quarrel." Why does it work?

I have spoken of the bee as a combination of hereditary structures and behaviors. But it must be remembered that the parents of worker bees are drones and queens, and these parents do not have the characteristic structures nor the industrious or warlike habits of workers. How can workers inherit characteristics which their parents do not possess? Only, as some wag said, by inheriting from their maiden aunts.

While this inheritance has been considered a problem, it is really not so. Or, rather, it is a commonplace problem, and part of all considerations of heredity. Bees are improved by breeding from those queens whose offspring are most productive and least irritable. And nature too has certainly bred from those queens whose offspring best fitted themselves to their surroundings.

It is very easy for me to believe that the bee is a kind of automaton—a complex of physico-chemical reactions bound by and leading to a complex of behavior patterns—and that all is dependent on the nature of the materials and forces of our world and the million-year-old inherited experience of bees. But if that conception of the bee is true, what am I? If the bee could observe me as objectively as I observe her, would she not define man in exactly those same terms? Can she do otherwise? Can I do otherwise?

SCIENTIFIC PROGRESS AND THE EVOLUTION OF CAPITALISM

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Nature of Capitalism

It is necessary for the purpose of this paper on the evolution of the capitalist system in relation to scientific progress to attempt first a statement of the essential characteristics of capitalism, even though it would be difficult to obtain among economists a general acceptance of the characteristics as herewith given. Capitalism must be viewed not narrowly but broadly as an integral part of civilization. To understand the nature of capitalism it is necessary to consider not only its economic but also its non-economic characteristics, including the psychological, social and legal. From the economic viewpoint, capitalism is a system wherein the activities of production, consumption, distribution and exchange acquire certain distinctive characteristics. Under capitalism production is essentially large-scale in nature, and consequently seeks a widening market. Capital becomes of increasing importance as a factor in production, and labor is free to sell its services for a wage. Consumption is varied in nature, since income determines the needs of society, instead of the needs governing income, and the distribution of income among the members of society is such that a large proportion goes to a so-called middle class. The exchange system is conducted indirectly through the mediation of money and credit, and so capitalism operates under a price system with valuation having a definite pecuniary significance. Viewed from the standpoint of psychology, capitalism flourishes because of the profit motive in human beings who are driven to economic activity because of the urge to acquire greater income and wealth not for use but for the sake of having income and wealth. Capitalism possesses the social characteristic of a growing urban population. It also implies the legal concept which recognizes and protects the rights of private ownership of property. Under capitalism the technocological characteristic of labor-saving devices in the form of machines is well developed.

Certain political characteristics are also frequently considered as necessary features of capitalism. It is held that imperialism, in the sense of an aggressive over-seas expansion by political force, is an essential concomitant of capitalism. However, imperialism was present before the coming of capitalism, such as the expansion of the Athenian state, while imperialism was at a low ebb in the first half of the nineteenth century under capitalism. It is also maintained that liberalism is an essential institution of capitalism, but capitalism existed before the coming of liberalism, and moreover capitalism exists tő-day in lands such as Italy where liberalism does not prevail. It is, therefore, best to limit the concept of capitalism to the characteristics given above. However, consideration will be given to the political habits which characterized the various stages of social evolution.

We will now seek to trace the evolution of the institutions which constitute capitalism with particular reference to the relation between them and scientific progress. It is assumed that social institutions pass successively through a rising stage, a developed stage and a declining stage which embraces the rising stage of

the new institution which is replacing the old. It is, however, essential to note that such evolution does not take place in any fixed or rhythmic cycle, and static periodization of social institutions must be avoided, for in the developed stage there may well come a point of crisis where an institution may either enter the stage of decline or may go forward to even further development. It is also necessary to recognize the fact that some institutions of capitalism did not begin with capitalism, but were present in pre-capitalist systems. However, these institutions became stronger and more prevalent under capitalism than under the previous systems. It is quite probable that post-capitalist systems may similarly possess institutions which exist now in limited form under capitalism.

Pre-capitalist Systems

In order to understand how capitalism evolved it is essential first to review briefly the preceding systems in the history of civilization. These earlier systems may be termed the collectional, the nomadic, the city-state and the feudal. In Europe the collectional stage covered the period from the dawn of history until about 12,000 B.C., and over these many centuries society, organized in family clans, lived by directly appropriating the gifts of nature. In the nomadic stage, society grouped into tribes, made some technological progress through sharpening its crude tools by grinding and polishing and also made economic advance through domesticating animals. In time the nomadic tribal system gave way to the city-state such as Sparta, Athens, Carthage and Rome, which were essentially political organizations formed to protect the lives and property of their own members and to exploit the lives and property of others. As a result, the city-states often engaged in total wars, such as the struggle between Carthage and Rome, which were fought for many years and for the objective of destroying the enemy completely. Society now made definite technological progress, since it not only improved its tools but also learned mechanical principles, such as the wheel and axle for chariots and oars and sails for seagoing ships. The pyramids of Egypt and the aqueducts of Rome are enduring evidence of the technological advance of the city-states. It is interesting to speculate why this technological knowledge of the ancient world did not result in the development of the machine and its extensive application to economic life. The factors which prevented such a development of the machine in the ancient world were probably the existence of slave labor which, because of its cheapness and its inefficiency, nullified the practical use of machines, and also the lack of an adequate supply of metal for tool-making.

Notwithstanding these limitations, the city-state possessed to a degree some of the essential psychological, legal and social institutions of capitalism. The desire for acquiring wealth was strong as evidenced in the denunciation of the business class and of the usurers by the writers of the Old Testament. Ownership of private property gradually became recognized in the early Greek and Roman laws until they were codified by Justinian. In time not only rights of private property but also liabilities under contract and under debt were defined. Moreover, the city-state included cities where large numbers were centered, but the total population still lived in rural communities.

Feudalism

The city-state attained its highest development in Rome, and through the strength of its military power and the soundness of its governmental system this civilization flourished for several centuries. In the course of time even this powerful organization declined and was

replaced by feudalism which lasted for about a thousand years. Feudalism was essentially a military and legal system which sought to protect life and property after the collapse of the Roman Empire. In its early stage, from about 400 to 1000 A.D., one dreary century followed another with society falling to ever lower levels of human misery, and the flickering light of civilization was kept alive only in the monasteries. The one social achievement of the period was the contribution of early Christian thought in opposing slavery and preaching the principle of free labor. However, a large part of the population continued in serfdom.

The developed stage of feudalism, approximately from 1000 to 1400, witnessed social progress. The technological advance of this period is evidenced by the medieval cathedrals and guild halls which still remain. Western Europe now attained political, ecclesiastical and linguistic unity. For the first time since the fall of Rome a large part of Europe was brought under a single political control through the Holy Roman Empire. Also important was the unity of faith and the coordinated religious civilization of the Res Publica Christiana. This vast domain of the state and church was bound together by the use of the common language of Latin. Local economic coordination was accomplished in the rural communities through the manorial system and in the towns through the guilds. The inhabitants of the towns acquired the status of free citizens, but on the manors serfdom largely prevailed, and labor was generally not free to choose its occupation.

The economic policies of both the church and of the guild system aimed to restrain the growth of capitalist institutions. The church sought to check the profit motive by the theory of the just price and by the condemnation of usury. Thus consumers were to be protected from the avarice of producers, and borrowers safeguarded from the depredation of lenders. The guilds endeavored to stifle competition, prevent unequal accumulation of capital by one member as against another and enforce a standard living wage for all. Thus under feudalism, through authoritarian regulation, production operated in a local market essentially for use, to provide the individual member with the necessities for meeting his immediate needs, and expenditures for these needs were determined by the income of the individual. Unity and stability were the underlying aims of the system.

Rise of Capitalism

Leading students of capitalism are not in agreement as to the exact time of the rise of capitalism. Tawney places it in the eleventh century, and Sombart in the twelfth century. It is difficult to fix the time for the beginning of capitalism, but for this study it is sufficient to note that capitalism rose as feudalism reached its apogee after the thirteenth century.

From the fourteenth to the eighteenth century Western Europe experienced drastic institutional changes in its political and religious habits. In general unity gave way to variety and stability to flux. First the Holy Roman Empire yielded to national sovereignties. The growth of these national states had a beneficial and an adverse effect. On the one hand, it led to the more effective protection of private property rights within the new national borders and gave the necessary legal encouragement to the accumulation of capital. On the other hand, the growth of nationalism led to overseas expansion and to bitter international wars, particularly throughout the eighteenth century when the great colonial powers clashed in the valleys of the St. Lawrence and of the Ganges.

The second important institutional change was the replacement of Catholicism by numerous Protestant sects over

a large part of Western Europe. Society, no longer tolerant of the economic rules of the Church, turned to materialistic concepts of life; the individual no longer toiled merely to provide for his limited immediate needs, but, impelled by the new capitalistic spirit, worked to satisfy demand unlimited in scope.

For a number of years social scientists have been engaged in an acrimonious controversy as to whether the capitalistic spirit was the fundamental cause of the rise of Protestantism. It has been argued that Protestantism, and particularly Calvinism, recognized usury and other economic practices banned by the Catholic church, and that religion was thus employed to further the ends of the rising capitalism. However, as shown before, the acquisitive spirit existed even in the Ancient World, and it is probably nearer to the truth to say that Protestantism, as part of the Renaissance movement toward realism, encouraged thrift and hard work, thereby bringing about a changing attitude toward life and thus stimulated the growth of the capitalist spirit. Unquestionably the new social attitude introduced by the Reformation contributed to the decline of feudalism and the rise of capitalism.

Old Capitalism

The fifteenth and sixteenth centuries witnessed marked technological progress which deeply influenced all phases of European civilization. The discovery of the magnetic compass and the improvement of shipbuilding enabled Europeans to cross oceans, and the age of discovery followed: the printing press made possible the dissemination of the ideas of the Renaissance. New mining methods enabled the profitable exploitation of the mineral resources of Europe; and in southern Germany mining operations were conducted on a large scale, even in the form of what may be described as cartels. Technology affected not only the arts of peace, but also of war, for gunpowder smashed the last strongholds of political feudalism. The machine was extensively used in military operations, and war now required the services of the engineer as exemplified by Vauban.

The furnishing of capital and credit for all these operations made necessary the development of a financial system, including bankers, such as the Medici and the Fugger families, and exchanges for transactions in goods and moneys. As early as the twelfth century securities were used in financing business transactions, but such cases were very rare until the nineteenth century.

This period of incipient capitalism witnessed a rapid accumulation of capital. The influx of precious metals from South America, the extensive commerce in raw materials, foodstuffs and ornaments and the mining operations in Europe brought enormous profits. Not only did capital increase in amount, but it also changed in form and in social ownership. Under the feudal system capital was mainly fixed in the form of land, whereas under capitalism a large proportion was in liquid form such as raw materials and cash. To a large extent the social ownership of capital shifted from the landed aristocracy to the merchant and to some extent to the banking class. In many cases the wealthy merchant and banking families married into the old nobility to create a new aristocracy. For the greater part the new economic groups formed an ever-growing middle class of its own which for the first time became an important factor in the social order. Another important social movement was the growth of large cities such as Naples, Paris and particularly London.

Thus by the end of the eighteenth century the system prevailing in Western Europe had acquired the character-

istics of capitalism, as explained at the start. There were now the beginnings of production on a large scale, an expanding market, no longer local but now national in scope, the increasing importance of capital, a laboring class free to choose its own occupation, a varied consumption, a widening distribution of income with the rise of a middle class, a monetary and credit system, a strong profit impulse unfettered by the restraints of the church, the growing use of machines, the recognition of private property and the growing urbanization of population.

Rise of the New Capitalism

The end of the eighteenth and the beginning of the nineteenth centuries marked the passing of what may be considered the old capitalism and the coming of new capitalism. Over these years Western Europe, particularly England, experienced a rapid advance in technical knowledge, invention and physical science, generally described as the industrial revolution. To early commentators it seemed a new and sudden movement. However, as noted before, technological advance was moving forward for several centuries and so the industrial revolution was neither new nor sudden. The movement was, however, distinctive in that science, which had hitherto been the concern of a few intellectuals, now absorbed the interest of many hard-headed business men, who, as a result, hit upon important inventions and discoveries in textiles, transportation and other economic fields.

One of the distinctive institutions of the new capitalism was liberalism. It was essentially a revolt against the restraints of both the church and the state, and developed an intellectual attitude favoring individual freedom which exerted a profound effect upon society. Liberalism had definite political, economic and technological results. It led to the secularization of the state and the exclusion of the church from temporal affairs. Liberalism brought about the growth of democracy, the widening of suffrage and the development of representative government in the conduct of national and local affairs. In the economic field, the doctrines of liberalism were spread by the great classicists who preached individual initiative and laissez-faire, and urged the removal of the restrictions of the state from both domestic and international business operations. At home business was to be conducted on the basis of free competition, and abroad there was to be a world economy operated under free trade and the international division of labor. Science, essentially dynamic in nature, flourished under the freedom offered by the political and economic principles of liberalism.

Another potent institution of the new capitalism was the pacific nature of international relations in the nineteenth century. The Napoleonic Wars may be regarded as a continuation of the intense international rivalry of the old capitalism. The period from the banishment of Napoleon to St. Helena to the outbreak of the World War was comparatively peaceful in nature. True, these years were marked by several wars, but they were local in nature, usually short in duration, fought for limited objectives and their effects were not serious. Even the fires of imperialism abated after the virtual destruction of the Spanish and French colonial empires and after the loss of the Thirteen Colonies to Great Britain.

A third characteristic of new capitalism was the internationalization of the market. Under the old capitalism the market had expanded from a local to a national area, but under the new capitalism the market became thoroughly international in scope. The growing output of the factories was sold not only at home but also abroad. In addition there

was also the export of a growing volume of capital from such countries as England, Holland and Belgium.

A fourth important development under the new capitalism was the creation of a financial mechanism for mobilizing capital through the use of stocks and bonds. Under the domestic system of the old capitalism the worker supplied the fixed capital in the form of tools and workrooms, while the entrepreneur furnished the working capital to pay for wages and raw materials. This structure of capitalism was entirely changed by the technological improvements of the nineteenth century, for under the factory system of the new capitalism the entrepreneur contributed not only working capital but also fixed capital in the form of factories and machines.

In the past business was largely organized in the form of single ownership or partnership, and capital came from the entrepreneur or his associates. In the nineteenth century under the French Commercial Code and the British Companies Act, the corporation acquired limited liability and formation under a general rather than a special act, and as a result became the dominant form of business organization. Capital was now provided largely by the investor who purchased the securities of corporations and of governments.

Developed Stage of the New Capitalism

Throughout the nineteenth century the new capitalism moved from its early to its developed stage. This evolution took place at different times in the leading countries of the Western World. By the middle of the nineteenth century the old order in England, Holland and Belgium gave place to the new; by the end of the second quarter of the century France and the United States experienced the ascendancy of the new capitalism, and in the last quarter Germany, Switzerland and the Scandinavian countries attained this stage. The rest of Europe, as well as Asia and South America, continued in various stages of social evolution, and in some cases institutions of feudalism survived along with those of the old capitalism and of the rising new capitalism.

In the developed stage of the new capitalism technological advance was no longer left to the chance of the business man in his workshop but was largely the result of the systematic research of the scientist in his laboratory, particularly in the field of electricity and chemistry.

In the developed stage the distinctive institutions of the new capitalism grew stronger. Political liberalism made rapid progress with the creation of constitutional monarchies and of republics. The market became more and more internationalized in nature as the area of the enforcement of contracts widened, as currencies were placed on a gold basis and as uniform commercial codes were adopted. As a result the international flow of goods and of capital was encouraged. The financial mechanism for mobilizing capital through the flotations of stocks and bonds was perfected with the formation of powerful incorporated banks replacing the old private bankers and the operations of stock exchanges in the metropolises of Europe and the United States.

Under the new capitalism population experienced its most rapid increase in all history, for from 1820 to the outbreak of the Great War the number of persons in the world doubled. A large part of this increasing population was sustained at an ever higher standard of living, for income and wealth rose sharply and were widely distributed. In the latter half of the nineteenth century the standard of living of society as a whole was higher than in any other period of history, for the world was producing more coal, more iron, more cotton and more wheat, and at

the same time the consuming power of Western Europe and the United States was highly satisfactory. Unquestionably the developed stage of the new capitalism represented the highest level of social progress in all the history of civilization. These conditions refuted the gloomy Marxian forebodings of crises of increasing severity and of deepening social misery, resulting in the disappearance of the middle class and eventual revolution. The error of Marx lay in the fact that he mistook the passing of the old capitalism for the passing of capitalism as a whole, and although he recognized some of the characteristics of the new capitalism, he underestimated its strength.

In certain respects in both its early and developed stages the characteristics of the new capitalism were the same in nature as those of the old capitalism but only more pronounced. The technological advances of the industrial revolution, although on a greater scale than before, merely continued the progress of the previous centuries. Similarly, the economic characteristics were about the same as before but only more intensified. Production had been expanding throughout the seventeenth and eighteenth centuries, but the sweeping technological improvements tended to increase production more rapidly. Consumption for several centuries had become more varied, but as factories turned out their increasing production, the consumptive habits of the peoples of Western Europe became much more diversified. As the factories drew workers from the farms, the trend toward urbanization, in progress for several centuries, became more rapid.

However, it is clear that the new capitalism acquired definite characteristics of its own. The philosophy of liberalism completely changed the political nature of European civilization and replaced autocratic governments with limited monarchies and republics. Moreover, the international struggles of the eighteenth century were followed by a period of relative peace. Manufactured goods were produced not only for home consumption but for export, and the market now became international in character, for goods and capital flowed freely among nations. The mechanism for mobilizing capital and credit changed, since private enterprise organized as corporations and also governments obtained their funds largely through the flotation of securities. The distinctive characteristics of nineteenth century capitalism in its early and developed stages were, therefore, its liberalism, its pacific nature, its international economic market and its mechanism for mobilizing capital by the use of securities. The civilization of Western Europe in the nineteenth century may therefore well be described as a liberal, pacific, international security capitalism.

Crisis of the New Capitalism

Even before the outbreak of the World War, these distinguishing institutions of the new capitalism were beginning to lose their strength. While the political doctrines of liberalism continued to spread, its economic principles were being checked. There was an increasing extension of governmental regulation of national and international business activities not only in countries such as Germany, which never really accepted the doctrines of economic liberalism, but even in England and in the United States. Moreover, the era of international peace was passing, for the imperialism of the old capitalism revived and the leading nations of Europe once more brought large overseas territories under their jurisdiction. The last decade of the nineteenth century witnessed the beginning of the armament race, which was to culminate in the catastrophe of August, 1914.

In the post-war period there were definite changes in the distinctive institutions of the new capitalism, with partic-

ular reference to liberalism, international political relations, international markets and the security mechanism. The post-war period experienced a decline of liberalism and a rise of fascism. In the leading liberal nations, constitutional government was seriously weakened, and in other countries political power was usurped by communism and fascism. Fascism is to-day exerting as determining a force on the capitalism of the twentieth century as did liberalism on the capitalism of the nineteenth century. In authoritarian philosophy fascism is regarded as the inevitable outcome of the declining stage of a matured capitalism. As a matter of fact, fascism has made its greatest progress not in countries where the new capitalism attained its highest development but in those countries where its appearance came late. Germany was the last of the great capitalist countries to enter the stage of the new capitalism, while in Italy it made slow progress before the war and in Japan the system has not even outgrown some of its feudal characteristics. Fascism in these countries has rather been the result of the collapse of an immature new capitalism with insufficient strength to bear the war and post-war burdens which only a developed new capitalism could support. Fascism, with its repudiation of liberalism, its militarization of society, its desire for economic self-sufficiency and its effort to abolish the private security mechanism, is diametrically opposed to the distinctive features of the new capitalism. In fact, fascism with its emphasis upon authority, stability and unity, its limitation on the profit motive, its impairment of the concept of private property rights, is in part a reversion to feudalism.

The international political relations of the twentieth century also constitute a drastic change from those prevailing under nineteenth century capitalism. Not only was the period of comparative peace followed by war, but the character of war reverted to the nature of pre-capitalist conflicts in the sense of total wars for the purpose of crushing the enemy completely and keeping him subjugated irrevocably under a Carthaginian peace. Modern war, perfected by the application of science, is to-day not only disastrous for the vanquished but also for the victor, since the new capitalism mobilizes all nations so efficiently that victory is followed by the complete exhaustion of material and spiritual resources. Imperialism also has changed in nature, for while in the nineteenth century the great powers expanded their colonial empires by acquiring the territories of weak states, in the twentieth century, since there are no longer new colonial areas, the powers seek to wrest overseas possessions from each other.

Another serious impairment of the distinctive features of nineteenth century capitalism has been the narrowing of the international market. The flow of goods and capital among nations has been seriously impeded by restrictive measures such as mounting tariff barriers, embargoes and currency regulations. Not only have the fascist nations checked the international movement of goods and capital, but even liberal countries have followed restrictive policies. Regulations for the protection of private property in foreign countries have been swept away, the actual confiscation of property during the war and the virtual confiscation during the depression have struck serious blows at the international markets of the new capitalism. As a result world trade has declined and the export of capital has virtually ceased.

The security mechanism of modern capitalism has also been shaken to its very foundations. In almost every country the increasing instability of security prices has brought heavy reverses to banks which have been seriously weakened so

that government support has been necessary, private capital markets have almost ceased to function and the stock exchange operations are near a standstill. Demand for capital comes mainly from the national governments which float securities largely for armament expenditure and unemployment relief. As a result of public debts created mainly for unproductive purposes supported by a dwindling proportion of wealth, and interest payments covered by a declining amount of national income, the quality of public credit has depreciated.

Conclusion

From this paper, which has sought to review the evolution of the institutions of capitalism, it is clear that these institutions, being dynamic in nature, are ever changing and are ever giving way to others. The tempo of this change is now more rapid than in the past, and so the replacement of older institutions with new is at a much quicker pace. We are in the current of an ebb tide drawing society from the system of the nineteenth century capitalism which, as a result of scientific advance, gave the world the highest level of material welfare in the history of civilization. The essential institutions of this system, namely liberalism, international peace, an international market and a private security mechanism, are declining, and in some cases are even being replaced by pre-capitalist institutions.

What are the problems of the relation of science to these changing institutions of our present-day capitalism? First, can science, which flourished under nineteenth century liberalism, continue to progress in an atmosphere of quasi-liberalism or fascism or communism, and can the spirit of inquiry explore the still unchartered fields of science in an environment which stifles the free expression of the individual? Can science continue to improve the art of war without itself being destroyed? Can society reap the benefits of scientific advance in the form of a high standard of living and high national income in a self-sufficient national economy? Can capital and credit to finance scientific advance be obtained if the private security mechanism does not function? These are the problems which confront the physical and social scientists, and these are questions which press for an answer.

A QUANDARY FOR SCIENTISTS

Much of the world is at war. We are fortunately able to stand aside, but no evaluation of the condition and program of an institution can be completely divorced from the stress of the times in which it operates. Even in these fortunate United States all plans are thus conditioned, and every individual is thus affected.

The scientist in particular is faced with a quandary. The same science which saves life and renders it rich and full, also destroys it and renders it horrible. Is it then possible to remain in a detached atmosphere, to cultivate the slowly growing body of pure scientific knowledge, and to labor apart from the intense struggle in which the direct application of science now implies so much for good or ill? As with an individual, so with a scientific institution; we can not consider the immediate future of the Carnegie Institution without taking cognizance of the conflict of emotions which is inevitably present.

The quandary may be immediate and direct. Science and its applications have produced the aircraft and the bomb. Entirely apart from all questions of national sympathies, from all opinion concerning political ideologies, we fear to witness the destruction of the treasures of civilization and the agony of peoples, by reason of this new weapon. As science has produced a weapon, so also can it produce in time a defense against it. Science is dedicated to the advance of knowledge for the benefit of man. Here is a sphere where the benefit might perhaps indeed be immediate, real and satisfying. Can a scientist, skilled in a field such that his efforts might readily be directed to the attainment of applications which would afford protection to his fellow men against such an overwhelming peril, now justify expending his effort for any other and more remote cause?—*Report of the President of the Carnegie Institution of Washington, 1939.*

THE PREDICTION AND CONTROL OF ACCIDENTS

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UNTIL quite recently it was customary among many engineers and many psychologists, as well as among the lay public, to look upon industrial and traffic accidents as primarily due to chance factors which could not be brought under control. More recently there has been a marked tendency to ascribe many accidents to personal behavior in the individuals concerned; that is, to variations from a standard pattern of right and safe behavior. The remedy obviously lay in training, since the deviations were assumed to be matters of habit that were largely under voluntary control.

The effectiveness of the extensive and intensive safety training programs has often been startling. In some instances they seem to have almost reached the limits of effectiveness, considering the time and effort devoted to them, but accidents continue, withal at a lower rate. The means of control have not, however, been exhausted.

Investigations by Greenwood and Woods in 1919, followed by that of Newbold in 1926 covering 16,000 British cases, and further supported by the findings of Bingham and others in the United States, point to one conclusion: There are some individuals who are, by reason of certain inherent characteristics, predisposed to have accidents. It was upon such a conclusion that the experimental investigations of Farmer and Chambers were predicated.

These latter investigations, made under the auspices of the British Industrial Fatigue Research Board and published in its series of bulletins, demonstrated conclusively the possibility of further reduction of accidents through the identification of individuals having the accident-proneness characteristics. Their results indicated that the selection of industrial workers by tests would effect a 50 per cent. reduction of accidents, since it has been well demonstrated that the most able workers are also the safest and that work done correctly is done safely.

The British investigators found no relationship between intelligence, as usually measured, and the accident records. They did find, however, that three tests of the considerable battery used showed substantial relationships with the records. These three tests were choice reaction time, dotting and the pursuit meter, all well known to psychologists.

It is important to note that each of the three tests involves the use of attention and perception in conjunction with muscular movements in its performance. Since it was quite impossible to separate the perceptual factor from the motor control factor, the two entered into the final scores in unknown amounts. The effect of this was to reduce the amount of actual relationship that was present in the data.

A smaller investigation made some years ago by this writer indicated that only moderate relationships between accident records and tests were obtainable when scores were handled in the conventional method used by the British investigators. Far more significant relationships were found when the *differences between scores* on perceptual and motor tests were compared with an index that took account of both frequency and severity of accidents.

The foregoing results lead to the hy-

pothesis that accident-proneness is a phenomenon associated with discrepancies in level between perception and motor reaction. It was observed that persons whose perceptual level is equal to or higher than their motor level are relatively safe, while those whose perceptual level is lower than their motor level are accident-prone, with records of more frequent and more severe accidents than the former group. This implies that those who can see faster than they can react are relatively safe, while those who react faster than they can see are accident-prone.

It does not follow, however, that all uncorrected defects of vision contribute directly to slow perceptions and thus to accident-proneness. It is apparently possible to have a variety of such defects and still get perceptual cues that are quite adequate for effective and safe behavior. While defective vision tends to reduce the speed of perception, this latter may not be reduced below the level of the motor reactions and thus make the person accident-prone.

There is some evidence to indicate that certain individuals suffer an early and rapid breakdown of the speed of perception under the influence of fatigue, alcohol and distraction. In others the breakdown seems first to affect the speed of motor reactions, leaving the speed of perception relatively unimpaired. This latter group would tend to be relatively safe under these influences as long as the perceptual level is not reduced. On this hypothesis, however, the introspective evidence of the individual himself should not be sufficient to justify his working at a dangerous task while excessively fatigued or driving his automobile while intoxicated. The foregoing evidence does raise some doubt as to the validity of measures of vision and of the alcoholic content of the blood as bases for a judgment of impaired skill and safety. The effect of these latter on perception seems to be the real criterion.

In order to make such comparisons of levels it is necessary to reduce the scores on the tests to some common scale by one of the usual statistical methods. It is necessary also, in any further and more exact measurement, to design tests that will give measures of the function intended that are as free as possible from other complicating factors. That is, a measure of visual perception should be as nearly free from the motor factor as it is possible to devise it. A motor measure should be practically free from the perceptual factor. While the correlation with each other of the tests used by the writer was only .30, this figure indicates an amount of overlapping that can be still further reduced.

It is significant that in the writer's investigation two relatively safe groups of industrial workers were found—the very good piece-workers on assembly operations and the very slow group of day-rate workers. It would seem that the latter avoided accidents by a slow rate of work. This is shown in Table 1.

TABLE 1

Foreman's ranks (earnings)	Sum of index figures, by eighths	Sum of index figures, by quarters
1–5	2.24	4.83
6–10	2.59	
11–15	2.01	7.28
16–20	5.27	
21–25	4.49	13.35
26–30	8.86	
31–35	1.88	7.27
36–40	5.39	

The preponderance of accidents in the third quarter of the group—the quarter containing the workers who were barely making the piece rates—is striking. If tests had been used in employment selection, most of the persons in these two lower quarters would not have been employed. This alone would have effected a reduction of accidents amounting to 55 per cent., a result that compares favorably with the estimate made by Farmer and Chambers. If the difference-scores had also been used for selection, the reduction would have been much greater.

Table 2 shows, for the same group, the marked tendency of the difference-scores to pick out the individuals with the high frequencies and severities:

TABLE 2

Difference scores (perception minus motor)	Sums of accident index by Eighths	Quarters	Halves
+ 60 to + 29	.71	4.29	7.71
+ 23 to + 18	3.58		
+ 15 to + 8	.57	3.42	
+ 6 to − 5	2.85		
− 6 to − 11	2.88	6.57	25.04
− 12 to − 15	3.69		
− 15 to − 21	9.00	18.47	
− 21 to − 48	9.47		

If employee selection were made using both methods of test score application, a reduction in the average accident index of as much as 75 per cent. might be achieved, and this quite independently of other safety education and training measures. In fact, in one group of new employees thus selected, the actual reduction was 70 per cent., in comparison with the records of a group selected by the usual interview technique.

A still further reduction in accidents might be achieved by classifying jobs and work areas in terms of the hazard they present and assigning to the most dangerous work the applicants least likely to have accidents, and to the least dangerous work the applicants most likely to have accidents. By this method a given set of workers could be distributed so as to effect a substantial reduction in accident rate and severity.

What are the prospects for attacking this apparently inherent accident-proneness in some persons by education and training? It must be confessed that the results of the attempts to modify the test scores by training have been discouraging. The tests seem to be measuring innate qualities that can be modified only slightly and that with great difficulty, perhaps only temporarily.

The better approach to control seems to be to discover the degree of proneness of a person and then to place him in an environment in such a way that he will not be subjected to hazards beyond his tested limitations. Knowing his limitations, he may, by the exercise of judgment, avoid situations that would result disastrously. If the hypothesis is correct, and if the measurements represent a new area of stable individual differences, the airplane pilot, the automobile driver and the dish-breaking domestic servant are as suitable subjects for testing as is the industrial worker. One of the interesting characteristics of the proposal is that since the measurements can be made before selection and before training is undertaken, many severe and some fatal accidents may be avoided.

ON SCHOLARLY WRITING AND CRITICAL REVIEWING

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The Scholar

A scholar is one who loves learning for its own sake and will peruse the record because he reveres it. He will never imitate those who write as if nothing had ever before been disclosed in their fields of inquiry. Certainly he will not agree with those who frankly say they are interested only in their own research and do not care what others may have done. He will realize that a well-rounded review is much more useful than scraps of new, or supposedly new, information. Failure to summarize previous work is lamentable not only as indicating ignorance or lack of appreciation of pioneer endeavor, but is furthermore actual treason to scholarship because it handicaps the education of later students. Giving due attention to previous work is by no means detached altruism, for it may result in many a suggestion or ripen many an inspiration bearing on the scientist's own studies. Knowing what has been done is especially useful in forestalling futile repetition of argument or research and in preventing foolish claims of originality. In a word, acquaintance with one's subject, the more complete the better, is advisable for the strictly practical reasons of avoiding mistakes and evading criticisms.

The aphorism that "Art is long and life is short," doubtless inspired in Hippocrates by the study of medicine, applies as well to most research. The difficulty of accumulating adequate material, the need of painstaking study and reflection to get the most out of it, the requirement that every profitable method of approach be utilized, both in the field and in the laboratory, and the necessity of collating pertinent knowledge from every related field so that findings may be properly interpreted—the overcoming of these difficulties and the satisfying of these needs are not the work of a moment. The scholar must, therefore, have patience and an underlying persistence in pursuit of the truth that is something far deeper and better than the more lauded, but often superficial and unproductive, trait called enthusiasm.

The scientist, the scholar searches for truth but accepts the fact that his findings are only approximations to the truth. He strives ever for verification of previous, and for accumulation of new, knowledge so that there may be better and better approximations to truth. He is therefore tentative in expression and humble, not dogmatic, in attitude. He does not perform research to get support for a belief or policy; he does not anticipate or predict the results of research; he awaits them. Because he has no fixed expectations, he is not disappointed by the way the finger of truth turns. What appears to be truth suffices for him and is accepted for what it seems to be worth until something better can be developed. Indeed, as he must have reverence for the past, must be industrious in his calling, exhibit not only persistence but patience and moderation and abide always by the truth so far as it is possible to know the truth, the scientist must exemplify in his own person about all the qualities implied in the phrase "a gentleman and a scholar."

Scholarly Writing

To be scholarly in writing means to manifest learning. Good composition

granted, scholarly writing is that clearly showing mastery of its subject. This requisite prevails in both current and historical senses. The scholar must know not only his own research but that of other students in the same and related fields. Without knowledge of the foundation and progress of one's subject, it is impossible to be scholarly. The scholarly attitude implies devotion that tolerates no slackness of effort and reverence that appreciates the accomplishments of predecessors.

Scholarship seems difficult, yes, *is* difficult. It should be the goal of all scientists, yet when pursued too far, it becomes a quest for a perfection that is unattainable. Those who insist on completeness of knowledge and final accuracy in every detail will never finish their work. For production, there must be a compromise, say at a point where, under the circumstances, one has done the best one could. The compromise writing should, however, be as scholarly as practicable—a consummation that should be aided by editors, and held up as an ideal by critics—reviewers who though often disparaged are, at their best, essential to the building and maintenance of high standards of composition and worth.

Tasks for the Editor

In view of these praises of scholarship and scholarly writing, it is certain that editors will feel that most of their experience with these commodities has been in their tentative or formative stages. Scholars there must be or there would be no meaning in the word. Most of the scientific writing that comes through editorial channels, however, is not contributed by finished scholars. As in all lines of endeavor, it is the lower ranks that are most crowded. Neophytes do the bulk of the writing and they need the help of editors far more than they receive it.

Institutional editing, in general, is well organized and efficient, giving a good degree of dignity, accuracy, and clarity to its products. The less formal and mostly unpaid editing of scientific periodicals, however, is often not attended with such favorable results. In a good many instances, apparently, no real editing is done. A few commas may be added or tables and bibliographies made to conform to the adopted style, but on the whole, manuscripts are merely accepted or rejected. This practice evades editorial responsibility and is unfair in that a well-written paper may be accepted, though deficient in accuracy, while a "diamond in the rough" so far as substance is concerned, may be rejected. To contribute to the advance of knowledge, it is just the authors of these promising but poorly expressed articles who should be helped. Editorial efforts spent in aiding these writers with references, supplementary information, and suggestions as to better expression will in most cases be appreciated and, in the long run, will be repaid a thousandfold in terms of improved scholarship.

Writers not always being as scholarly as could be desired, editors should improve their product, certainly not print it just as received. One must wonder why an editor recently permitted an author to state that a certain wild duck is wholly a vegetable feeder when reference to an easily available compendium would have revealed that the statement is inaccurate. Why did another editor pass the statement that a specified invertebrate has no parasites and no enemies, when probably not a single organism in the world enjoys such advantages, and in the same magazine a few years previously there had been an article devoted to the bird enemies of this very creature?

Again we read in an ornithological periodical an assertion that the finding of some badly mutilated bird bodies washed ashore at a certain place extended the range of the species some 400 miles. Such records prove nothing as to the range of birds, as was pointed out in the same journal nearly twenty years be-

fore by its very capable editor of that period.

Why do such slips continue to occur? The main reason, seemingly, is that the prime canon of scholarship—knowing what has gone before—is not observed either by authors or editors. To many, abstracting media, summaries of literature, bibliographies, and indexes apparently mean nothing. There are "none so blind as those that will not see."

Critical Reviewing

It is not pleasant to be a critic, at least not permanently so, for there are repercussions. Hence critics, active in their youth and prime, usually mellow with age. Literary authors stung by criticisms have condemned critics as men who have failed in literature. But in American science this is distinctly not true; three of the leading ornithological critics, for instance, were Allen, Coues, and Merriam—all outstanding writers.

Like a leader of the flock in the theological field, the critic apparently is one who is "called." What calls him usually is inaccuracy, disregard of background, or reckless speculation that clashes so severely with the standards he prizes that he can not remain silent. In other words, it is departure from scholarliness, perpetrated by authors and permitted by editors, that arouses the critic so that he feels he must speak.

If unreliable writing is allowed to pass unchallenged, many in these days of specialization, when practically every scientist outside of his specialty is a layman, will perforce be deceived. In view of that situation and of the ever-increasing flow of publication, the need for critical reviewing is greater than ever before. Yet the practice is manifestly decadent.

Formerly, under the system of rugged individualism, the critic was encouraged; now under the brotherhood-of-man philosophy, he is discouraged. The proletariat of science distrusts one who still adheres to principles and puts accuracy above expediency.

To an old-fashioned critic, it appears nowadays that no matter how trivial the topic nor how ill-judged the content of an article, if it be presented in "constructive" form as an alleged contribution to knowledge, it is accepted for printing. On the other hand, a review calling attention to crudity, incompleteness, or illogicality of a published paper is rejected as being "destructive."

Limitation of discussion is not in accord with the spirit of science, in which all questions should be forever open. Suppression is alien to science and should be also to publishing media and institutions dealing with any phase of science. Suppression is a trait of authoritarianism which the proletarians usually get for their pains instead of their vaunted brotherhood.

Critical writing is equivalent to discussion at meetings. That is usually allowed and is sometimes as liberally provided for as are formal contributions themselves. A meeting at which discussion is not permitted is generally regarded as unsatisfactory, and the parallel situation in publication is equally so.

Even if other disciplines reject them, science should preserve and encourage its critics. A true scientist is a born sceptic, so why after retaining that quality long enough to make progress in science should he discard it? Scepticism, wholesome doubt, is among his most useful tools and its manifestations in a critic should be welcomed, not condemned. Humanity tends toward mob psychology, but the scientist should remain himself, poised, observant, critical of all things. To become one of a mob is to desert science. Suppression of criticism, rooted in the fatally easy preference for ease and freedom from every irritation or annoyance, is such a desertion and is, in the present state of philosophy, desertion in the face of the enemy.

BOOKS ON SCIENCE FOR LAYMEN

PERSONAL PROBLEMS OF ILLNESS[1]

One of the best things about Dr. G. Canby Robinson's book is its title. The emphasis upon "The Patient as a Person" is one that needs to be made over and over again in these days of microscopes, Wassermann tests and Roentgen rays.

This book is a later version of the social service studies made first by Dr. Richard Cabot and given national stature at the Massachusetts General Hospital. It is made up of several hundred detailed case histories classified in accordance with symptoms or diseases and analyzed from the standpoint of diagnosis and treatment in relationship to environment. It becomes an up-to-date analysis of medical social service. It presents in a detailed way those human problems that are a part of every illness.

It is fortunate that Dr. Robinson is wise enough to emphasize the significance of personal inadequacies in the care of those who are apt to become clinical patients in our various medical centers. Personal inadequacy, together with faulty personal habits, creates, for many who are unable to provide care for themselves during illness, as great or greater problems than lack of economic protection.

The book brings out in a very thoughtful way the tendency of the physician to think in terms of disease processes and to fail to recognize the rather high percentage of neurosis in many patients with organic ailments. This is a distinct handicap which can be corrected in part through an adequate social service.

In discussing the changes that have taken place in medical practice the author brings out the reaction of the physician associated with clinics, who has to obtain scientific satisfaction for his achievements rather than those affectionate and satisfying relations experienced by the family doctor in simpler days.

If such books as this one are brought to the attention of the medical student, the young physician and the social worker we can expect that there will develop a better mutual understanding on the part of the physician and the various associates who have been brought in to help him in his care of the sick. This will all be to the benefit of the patient. As. Dr. Robinson states, human nature is such that in chronic diseases the doctor is usually not consulted until the patient can no longer maintain social efficiency in the home or at work or in the field of recreation. When this is combined with inadequate economic resources and with ignorance as to most diseases it makes necessary the group assistance required by the ordinary clinical and hospital patient.

Since the patient must live with himself for twenty-four hours every day and the physician sees him for but a brief period, such a study as the author has made is sure to show the physician much more that he can do than to diagnose and prescribe.

Ray Lyman Wilbur, M.D.

[1] *The Patient as a Person.* By G. Canby Robinson, M.D. xiv + 423 pp. $3.00. 1939. The Commonwealth Fund.

THE WORLD OF CREATIVE PHYSICS[1]

The main reason why any intelligent person should consider reading Dr. Harrison's book, "Atoms in Action," is that it is really the only good book available which tells what the science of physics *does* rather than *is*. It contains the practical answers to the natural question of any non-physicist: "How does the science of physics directly affect me?" The philosophy and the theory of physics are subordinated in this book, and some of

[1] *Atoms in Action.* By George Russell Harrison. Illustrated. x + 370 pp. $3.50. 1939. Morrow and Company.

the worldly products and everyday rewards of this resourceful and advancing science are exhibited. It is the purpose of the book to do this.

In carrying out his purpose, the author has not neglected the classic example of physics as the parent of the entire electrical industry nor other examples like it. His emphasis, however, is on the recent, the present and the certain to come. This makes interesting as well as informative reading—interesting largely because the author is a gifted writer, informative because of the wealth of his subject and because he has well selected and balanced the topics he covers. The author stands like a farmer "looking his meadows o'er," with pleasure, no doubt, at their pleasant and wholesome appearance, but primarily with an appraising eye to the harvest therefrom.

The chapters are somewhat romantically titled, *e.g.*, "Sound Rides the Wire," "Glass—More Precious than Rubies," "The Ransomed Electron," "The Capture of Melody," "Man Climbs the Winds" and others. We can not regard such titles as inappropriate, however, if we admit that there is romance in the birth and growth of such industries as communication and air transportation, to mention only two. These are only two far-flung great industries founded on physics, two among others of even greater importance. Dr. Harrison's book gives a carefully checked, non-technical account of the physical basis of wire and wireless communication, steam, hydraulic and electric power, artificial illumination, the recording of sounds and action, transportation by land, sea and air, the forecast of weather, the use of raw materials, the production and preservation of foods, the correction of seeing and hearing, the preservation of health and the treatment of disease. This is a partial list only.

To cite an example, the chapter, "When Physics Goes Farming" refers to a farm as "a packaging establishment where energy from the sun is bottled up in the molecules of matter and stored for future use." Later, "the great primary problems of farming, apart from fertility, involve investigating and controlling temperature, light intensity, soil mechanics, and water application and disposal, all of which are problems of physics and the technology which springs from physical science." This five to ten billion dollar industry every day uses more power, heat and light from heat engines and electrical generators, more control over natural growing conditions, better storage of products, faster and safer transportation to market, better methods of soil conservation and more powerful methods of combatting pests. The farmer finds it possible to grow commercially a greater variety of plant species and, in fact, new species have been artificially created. In all these aspects the science of physics has played a fundamental rôle.

No chapter is more revealing than "The Doctor and the Physicist," for even though we are familiar with the fact that advances in science have enabled the saving of countless lives, we do not recall often enough the careful and painstaking use of instruments and laboratory devices which, in the hands of the medical profession, are the agents of this accomplishment. In "Atoms in Action," Dr. Harrison points to the x-ray, the microscope, natural and artificial radioactive substances, infra-red rays, the electric surgical knife and hundreds of gadgets for diagnosis and therapy.

If there is any single conclusion to be drawn from the evidence set forth in "Atoms in Action" it is, in Dr. Harrison's words, that "Man holds within his hands the power to make the world virtually what he will."

Henry A. Barton

SCIENTIFIC HUMANISM[1]

This remarkable book was first published in the United States by Covici-

[1] *Man the Slave and Master.* By Mark Graubard. x + 366 pp. London: 10s. 6d. 1939. J. M. Dent and Sons. (New York: $3.50. 1938. Covici-Friede.)

Friede of New York in 1938. Unhappily, the American publishers were forced to retire from the publishing field shortly after the publication of Dr. Graubard's book, and it is no doubt owing to this cause that the book has not, in this country, reached as wide an audience as it deserves. The English edition of the book, which is here reviewed, represents a revised and rewritten version of the American edition, and is to be regarded as a second edition which supersedes the American edition and which is, indeed, superior to it.

In recent years there have been a number of attempts to integrate and coordinate the basic principles of general biology and its branches with the processes of man's social life, so that such relationships as exist between these too long divorced "universes" might be better understood. Unfortunately, the advocates of understanding have too often found themselves in the position of a barrister who has been briefed to plead a case without having been supplied with the evidence necessary to plead it. The material witnesses have generally been most recalcitrant, and all that has been effected has been a reconciliation between the two parties, dramatic rather than convincing, speculative rather than sound, demonstrative rather than demonstrated. The sad fact is that the case has usually gone astray because the advocates have been no better equipped than most sophists have ever been, and have lacked a really profound understanding of the laws, principles and precedents with which it is necessary to be familiar before one can place the proper facts in their proper relations to one another, and so build up a solid case and perform a harmonic integration of them. In the present instance it is our pleasant task to have to record that it is Dr. Graubard's distinctive achievement to have combined in himself the qualities of an acute and brilliant mind, which has undergone a rigorous training and discipline in several distinct sciences, and in each of which he has done distinguished work, namely, in biology, biochemistry, genetics, endocrinology and cultural anthropology. Dr. Graubard may perhaps protest that he has done little, if anything, in the field of cultural anthropology to merit such praise. But in this connection it may at once be said that the reference is to Dr. Graubard's achievement in the present work, for in the considered opinion of the reviewer, this achievement constitutes a far greater and vastly more important contribution towards an understanding of the fundamental principles of cultural anthropology than anything that was ever achieved by Sir James Frazer, of "The Golden Bough," and Edward Westermarck, of "The History of Human Marriage," two of the best-known workers and their works in this field. These men were fact-collectors, not integrators, and their rather eclectic methods do not appeal to modern anthropologists. But however good one's methodology may be, it is not enough to master the methods and some of the facts of several sciences, if one is to bring them constructively to bear upon the solution of socio-biological problems. In addition one must possess the rare ability to discern the relations which exist between the manifold aspects of the various fields of activity and of knowledge involved; in brief, one must possess insight. As any one who reads this book will soon discover, not only is the author unusually well equipped in the fundamental biological sciences, but he is also extremely well endowed with the insight of the great scientist. This is a good augury for the task he has set himself of correlating some of the basic principles of physiology, embryology, heredity, biologic, cultural and social evolution, and of indicating the benefits that knowledge of these principles brings to the solution of problems of race, eugenics, art, social progress,

democracy, habit, custom, moral and ethical ideals, and many other important matters that are of vital significance for the present as well as for the future happiness and development of mankind.

Dr. Graubard is a scientific humanist, and his party and his creed are combined in the single purpose of the welfare of the human species as a whole. Not humanity in the abstract, or as Dostoievski used to say, by the book, but the practical immediate material and cultural welfare of every individual. By the application of scientific methods and scientific principles to the education and the government of men in democratically organized societies—and Dr. Graubard points out that scientific humanism is possible only in democratic communities—Dr. Graubard believes that the welfare of man can be unequivocally achieved.

Dr. Graubard is no idle visionary—the true visionary can have no room for visions—nor is he, as Lancelot Hogben says of him, an exponent of a "robust materialism." Indeed, this precisely is what Dr. Graubard is not, for, like Jacques Loeb, the clear motive behind his work is of a profoundly spiritual content, and as he writes himself in his fine concluding chapter, "The Meaning of Scientific Humanism," "Man never lived by bread alone, difficult as the struggle for it was. He always had a spiritual craving which apparently yielded great emotional satisfaction and enriched his life.

"This craving expressed itself in mystic and religious beliefs but also included the desire for social justice. In fact, the mystical ideas of religion were symbols of social relations, aims and feelings. The elimination of this deep-rooted spiritual craving can only harm man. Science has dispelled the magical components of religion, but it can not destroy the social elements. These give our lives too much meaning, in fact, they give meaning and justification to science. Without the guidance of spiritual feelings life will become crude and pointless.

"Scientific humanism recognizes the spiritual desires of man and gives them concrete expression and guidance. It will be more gratifying than *past* philosophies because it is based on a knowledge of reality" (p. 353).

And that is the keynote of this closely reasoned book. The material facts of man's biological and social development are masterfully set out, and their manifold relations are discussed and illuminated always with reference to their meaning and utilization for the good of man, here and now. If man can not live by bread alone, neither can he live by science alone, *that* has become abundantly clear, for whether his spiritual cravings are of internal or external origin, they are always with him, and any philosophy of crass materialism which refuses them recognition must founder upon that inevitable rock. It is the great tragedy of our age that we have been too long avoiding the recognition due to the irrepressible spiritual qualities with which we are all endowed. These qualities must, and do, find expression, but if their existence is ignored, they are likely to find expression in confused, emotional, undisciplined, mystical, prejudiced ways. Scientific humanism can supply the guidance which the spiritual needs of man require. Facts are indispensable, but they are not enough. What is required is the humanely cultivated attitude of mind which will enable the individual to evaluate facts critically and humanely; for what, in the ultimate analysis, is the use of any scientifically established fact, unless it be humanely understood and humanely used? Perhaps the present state of the world is the best answer? Unquestionably the best exposition of what man has been, what he now is, and of the potentialities he possesses for being, is to be found in Dr. Graubard's brilliant book.

M. F. Ashley-Montagu

AMERICAN ASSOCIATION MEETING PLACE, JUNE 17–22

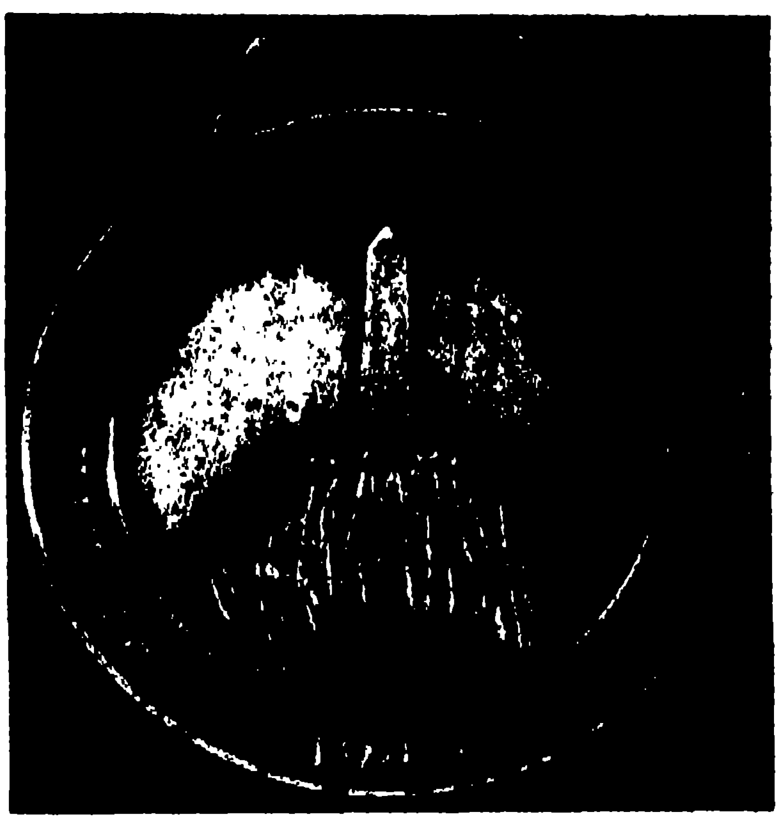
THE CAMPUS OF THE UNIVERSITY OF WASHINGTON. ON SHORE ACROSS THE BAY FROM THE LEFT IS THE SHOWBOAT THEATER AND THE OCEANOGRAPHIC LABORATORIES. BETWEEN THOSE STRUCTURES AND SLIGHTLY TO THE REAR IS HYDRAULICS LABORATORY. IN THE CENTER IS DANIEL BAGLEY HALL; IN RIGHT CENTER BEYOND THE UNIVERSITY GOLF COURSE IS ANDERSON HALL. OTHER BUILDINGS OF THE 582-ACRE CAMPUS ARE GROUPED IN THE BACKGROUND.

THE PROGRESS OF SCIENCE

MEETING OF SCIENTISTS OF THE AMERICAS

THE Eighth American Scientific Congress was held in Washington, D. C., from May 10 to 18. Though primarily scientific, the congress aimed to integrate science in the Americas with the social and political life of the people, for science can no longer be considered as separate and distinct from other forms of human activity. In our modern civilization science in one form or another enters into every element of our social structure.

Man as he used to be, as he is to-day and as he is to be in the future; his social organization, welfare and activities of every kind, and especially man in his relation to America and to other Americans—this was the broad subject that occupied the attention of the congress.



The formal opening of the congress on the evening of May 10 was featured by a stirring and memorable address by President Roosevelt, in which he referred feelingly to the invasion of Belgium, The Netherlands and Luxembourg, which had occurred a few hours before. He acknowledged with appreciation the great achievements of science in the extension and development of modern civilization, and said that the objectives toward which science is striving are closer and more peaceful relations between all nations through the spirit of cooperation and the interchange of knowledge. He deprecated the idea that science is responsible for the present "attacks on civilization which are in progress elsewhere," remarking that "The great achievements of science and even of art can be used to destroy as well as to create; they are only instruments by which men try to do the things they most want to do."

President Roosevelt's words made it very clear that although the participants in the congress were the twenty-one American republics only, the people of these American republics no longer can regard themselves as independent of, and insulated from, affairs in other portions of the world. Neither can science be regarded as distinct and apart from other forms of human activity.

Of most immediate interest to every one are the sciences grouped under public health and medicine. These in recent years have attracted much attention throughout the Americas. There were 119 papers presented in this—much the largest—section.

In order to keep track of health and other conditions affecting populations it is necessary to have at hand accurate and up-to-date statistical information. Throughout the Americas this is recognized as of vital importance. In the Section of Statistics there were 71 papers read by statistical experts from all the twenty-one American republics.

Although public health attracted most attention at the congress, the interrelations of the people, as individuals and collectively, and their relations to local and general conditions—included under sociology and economics—were discussed in numerous papers. These subjects were treated both from the point of view

THE HONORABLE SUMNER WELLES
UNDER SECRETARY OF STATE UNDER WHOSE PRESIDENCY THE CONGRESS WAS HELD.

of the several national units and from the point of view of a closer unification of the American republics.

A closer unification of the American republics envisions a greater uniformity in legal systems and in legal procedure than exists at present. There were 78 papers dealing with various aspects of international law, public law and jurisprudence. During the sessions the American Society of International Law, the American Law Institute and the Section of International and Comparative Law of the American Bar Association met in Washington, their programs to a large extent interdigitating with those of this section.

Education plays a large part in fitting individuals to take their proper place in the affairs of the communities in which they live. Education therefore occupied a prominent place in the proceedings of the congress. There were 61 contributions on this subject.

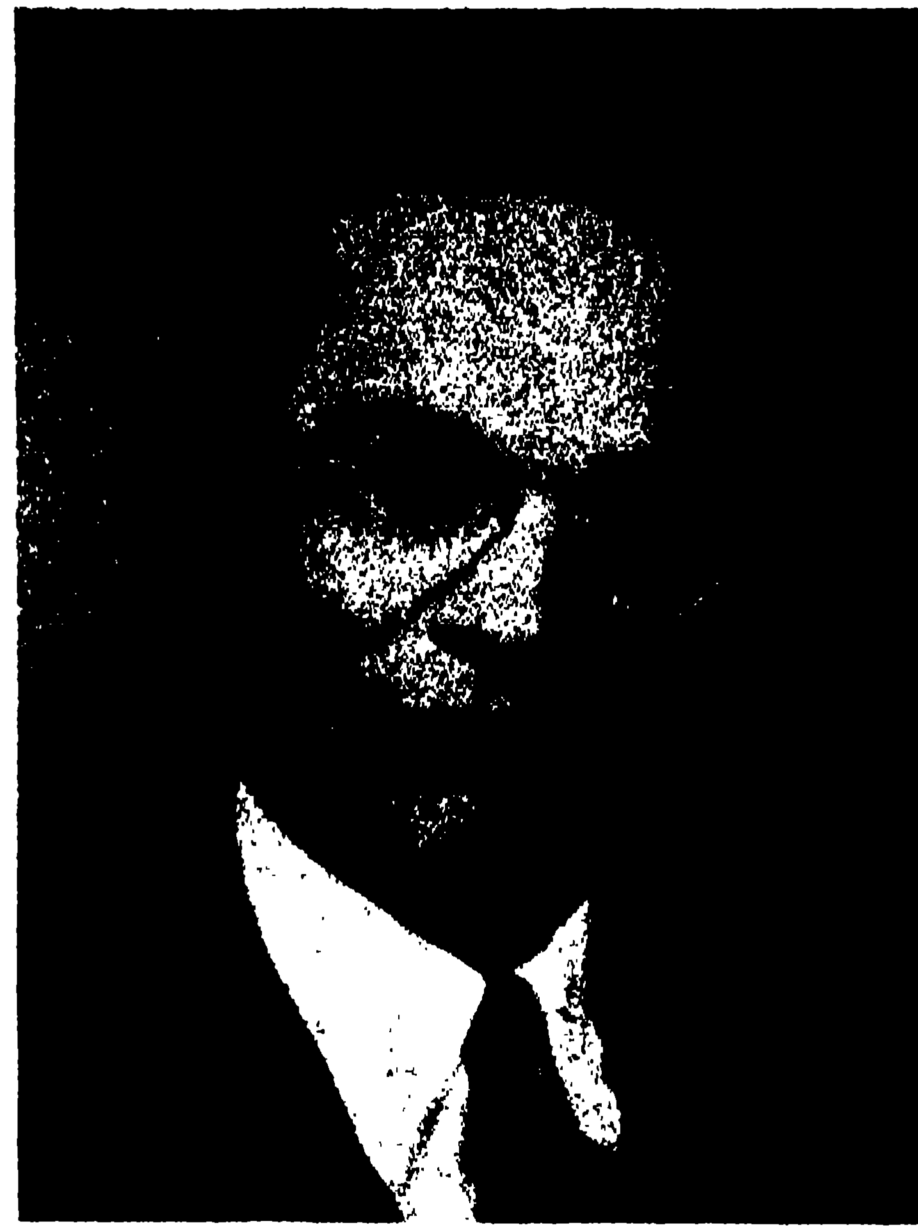
DR. HARLOW SHAPLEY AND PROFESSOR ALBERT EINSTEIN
WHOSE ADDRESSES CONSTITUTED A SPECIAL SESSION OF THE SECTION OF THE PHYSICAL AND CHEMICAL SCIENCES. DR. SHAPLEY SPOKE ON "HARVARD-PERUVIAN RESEARCHES ON GALAXIES"; PROFESSOR EINSTEIN SPOKE ON "CONSIDERATIONS CONCERNING THE FUNDAMENTS OF THEORETICAL PHYSICS."

The history and geography of a region determine the background and traditions of the people, their social structure and how they are supported. In this section there were 64 papers, dealing mainly with Latin America.

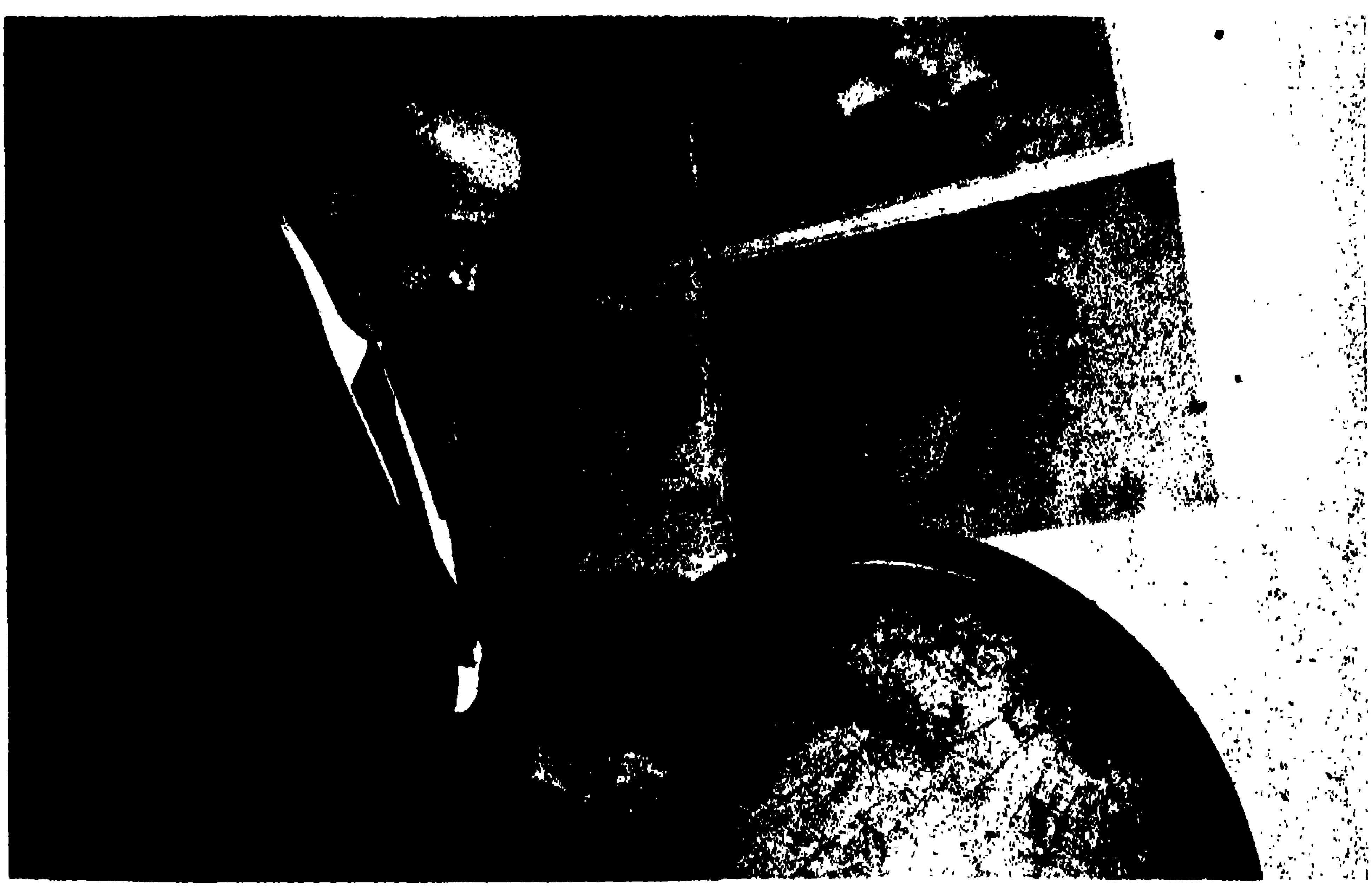
People in order to support themselves must make use of the natural resources of the regions in which they live, and because people must eat, the development and the conservation of agricultural resources is of first importance. These subjects were treated in 42 contributions.

Agricultural resources are supplemented by mineral resources, which were discussed in the Section of Geology. In this section there were presented 57 papers, covering practically all phases of the subject.

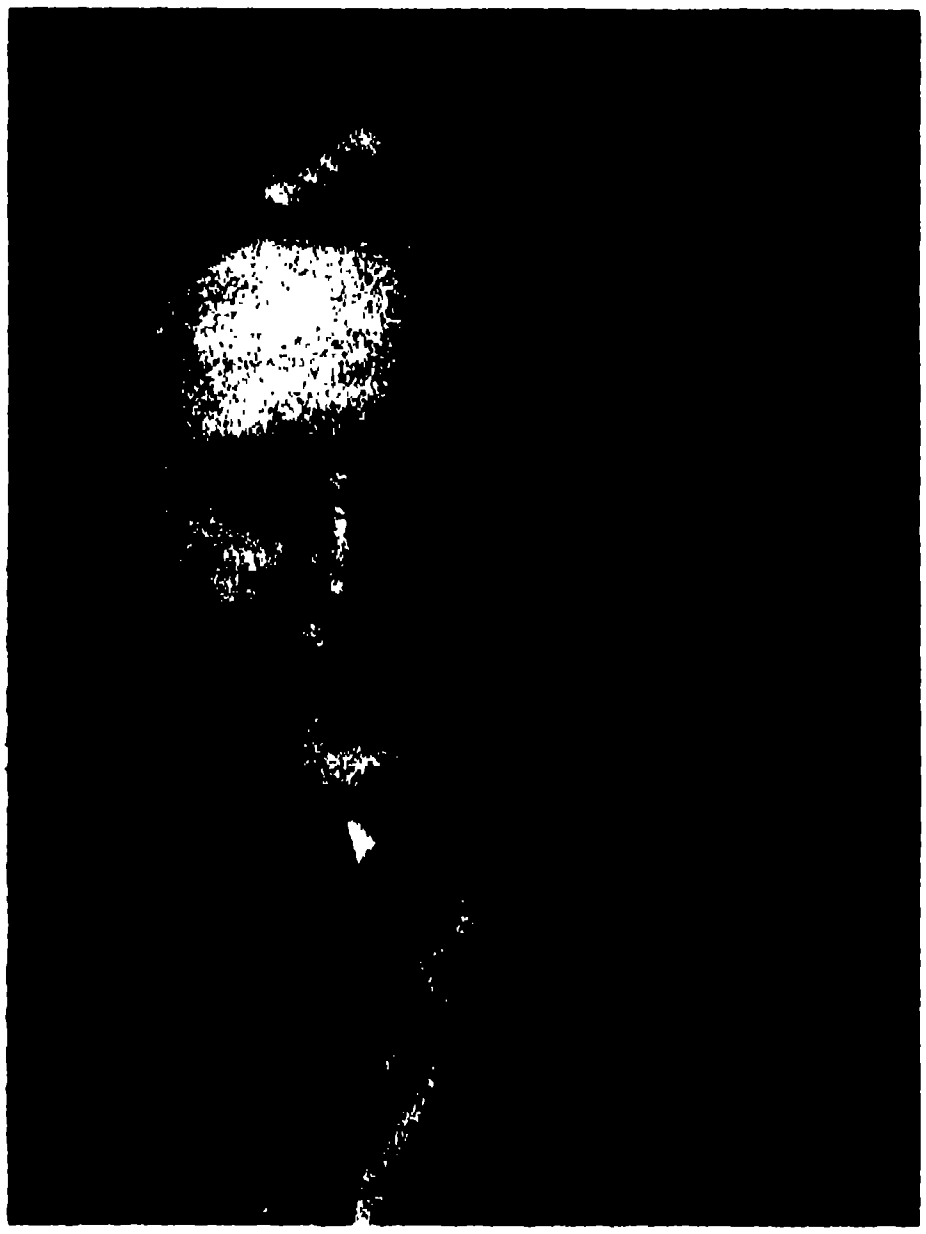
The proper utilization of the natural resources of any region is dependent upon proper appliances and methods for the cultivation of the land, for the extraction of minerals from the earth, for transportation and communication and for converting raw materials into fin-



DR. WARREN KELCHNER
CHIEF OF THE DIVISION OF INTERNATIONAL CONFERENCES OF THE DEPARTMENT OF STATE WHO SERVED AS EXECUTIVE VICE-PRESIDENT OF THE CONGRESS.



FROM THE HISTORICAL MAP COLLECTION OF THE LIBRARY OF CONGRESS
COLONEL LEWIS MARTIN, OF THE LIBRARY OF CONGRESS, TRACES THE LINE OF ISLANDS LINKING NORTH AND SOUTH AMERICA ON A GLOBE PLACED ON EXHIBITION.



DR. ALEXANDER WETMORE
ASSISTANT SECRETARY OF THE SMITHSONIAN INSTITUTION WHO WAS SECRETARY-GENERAL OF THE CONGRESS.

ished products of all descriptions. Here physics and chemistry play their part. In the Section of Physical and Chemical Sciences there were 62 papers. In all branches of science it is necessary to look to the future—to outline general plans or "laws" by means of which a multitude of apparently disconnected facts may be brought into correlation and thus take their proper place in a unified whole. This theoretical aspect of science has been especially developed in physics and in chemistry. Most important of the contributions under this heading was an address by Professor Albert Einstein on "Considerations Concerning the Fundaments of Theoretical Physics."

In the Section of Biological Sciences there were 79 contributions on a very wide range of topics in zoology and botany, and in the Section of Anthropological Sciences there were 77 papers covering all aspects of general archeology, psychology, general ethnology, physical anthropology, linguistics, folklore and the original peopling of America.

The scientific program was supplemented by an extensive social program. On Monday, May 20, the delegates visited Philadelphia as guests of the American Philosophical Society, the oldest of American scientific societies, founded by Benjamin Franklin, and on the day following they visited the New York World's Fair, of which they were the guests throughout the day.

The total registration at the congress was 1,750, but the attendance was probably nearly or quite twice that figure. There were 295 delegates from Latin America and 1,455 from the United States.

The congress was closed by President Sumner Welles with an able and vigorous address that followed the same lines as President Roosevelt's address of welcome. But he closed with a note of optimism:

"I believe—as firmly as I believe that the sun will rise once more to-morrow—that the present menace to civilization will pass and that the day will come when the now destructive forces of evil which men themselves have created will be vanquished."

AUSTIN H. CLARK

MEDALISTS OF THE NATIONAL ACADEMY OF SCIENCES

AN individual who renders unusual service in a special field of human endeavor deserves recognition and commendation from his fellow man. In the field of science appreciation of an important contribution to knowledge is expressed by the bestowal of an appropriate honor on the one responsible for the accomplishment. Universities confer honorary degrees; scientific societies award medals and honoraria in recognition of meritorious original work in science.

The National Academy of Sciences

awards, as a rule, four medals each year, chiefly in the fields of astronomy and astrophysics, of oceanography, of paleontology and of public welfare. Many branches of science are unfortunately not mentioned in the deeds of gift of the eleven funds entrusted to the academy for medals awards; because of this restriction, workers in these fields of research are not eligible for awards. Provision to remedy this situation will probably be made in the course of time by gifts made to the academy for the establishment of additional trust funds.

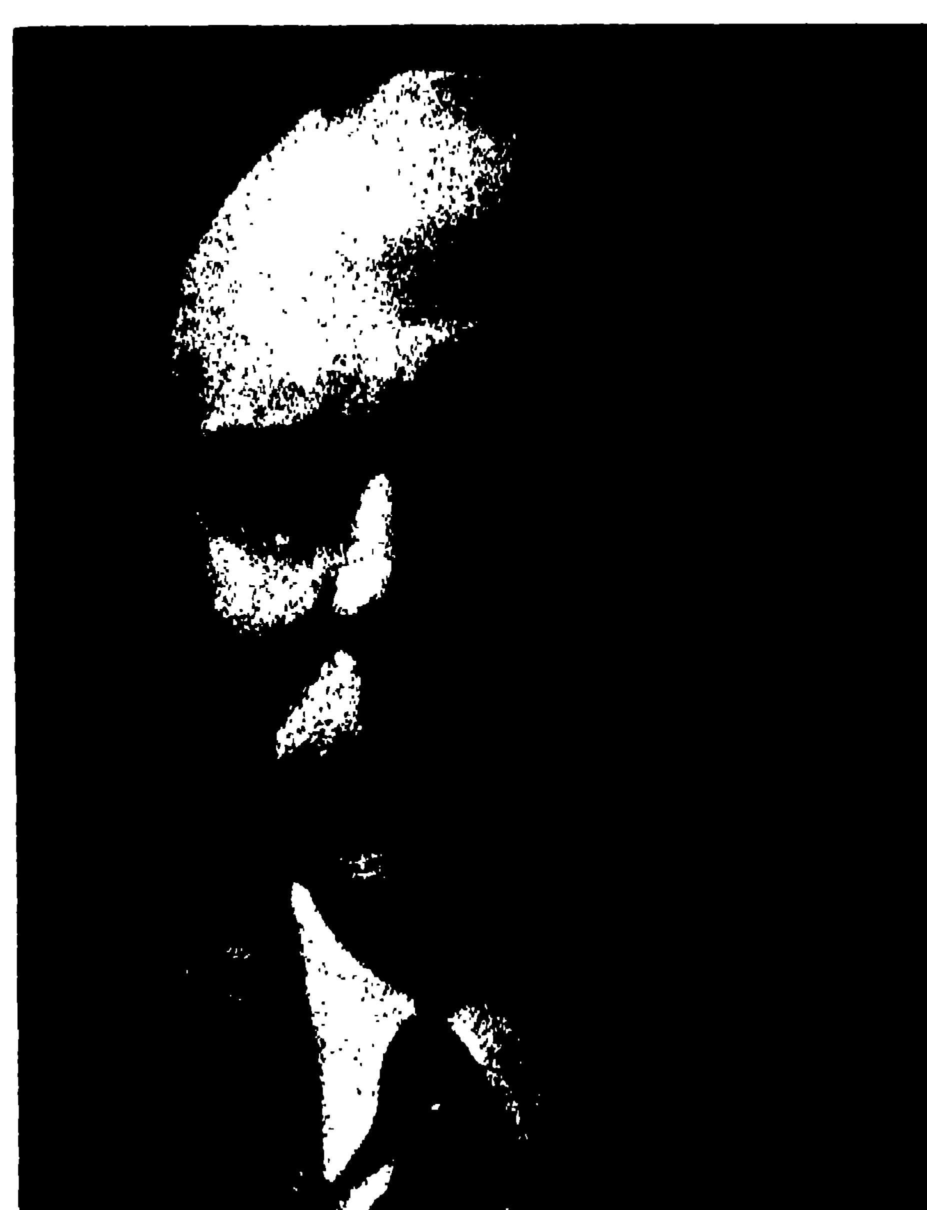
At the seventy-seventh annual meeting of the academy, held in April, three medals were awarded: the Agassiz Medal for Oceanography, to Frank Rattray Lillie; the Public Welfare Medal, to John Edgar Hoover, and the Charles Doolittle Walcott Medal and Honorarium to A. H. Westergaard.

In his presentation speech recommending the award of the Agassiz Medal, Dr. E. G. Conklin stated that:

> In these times of exaggerated nationalism it is fortunate that we can still emphasize the internationalism of science. The Murray Fund of the National Academy of Sciences is peculiarly international in its foundation and purpose. It was established in 1911 by Sir John Murray, Canadian by birth, Scot by adoption, internationalist in science, to honor the memory of Alexander Agassiz, Swiss-born American, cosmopolitan as the ocean in his research work. Of the seventeen awards of the Agassiz Medal which have been made hitherto, fourteen were given to foreign oceanographers, three to American. Of the foreign awards, five went to Norwegians, two to Swedes, two to Danes, two to Britons, and one each to oceanographers of Holland, Germany, and Monaco.
>
> The eighteenth award of this medal is to one who is a Canadian by birth, American by adoption and an internationalist in his sympathies and services, Frank Rattray Lillie, thirteenth President of the National Academy of Sciences. For twenty-six years he was Director of the Marine Biological Laboratory at Woods Hole, Massachusetts, and he was president of that institution from 1926 to 1939. . . .
>
> For his important researches and his wise leadership in marine biology, for his enduring contributions to the science of oceanography in the founding and endowing of the Woods Hole Oceanographic Institution, for his modest but effective leadership in causing this country to assume its share in a world-wide program of oceanographic research, the Committee on the Murray Fund presents to you, Mr. President, for the eighteenth award of the Agassiz Medal, Frank Rattray Lillie.

In response Dr. Lillie expressed pleasure in receiving the award but wished personally to emphasize the fact that he did so "in a representative rather than in a personal capacity. The accomplishments have been, indeed, the work of many minds and hearts." In his address he sketched the early development of the study of oceanography in this country and abroad and of the gradually increasing interest taken in it because of its scientific and economic possibilities.

In the presentation address for the Public Welfare Medal, Dr. Max Mason, member of the committee on the Marcellus Hartley Fund from which the award was made, stated that:



DR. FRANK R. LILLIE

DR. J. EDGAR HOOVER

By temperament, by tradition, and by resolution, the people of the United States are devoted to the ideal of human freedom and human dignity. This ideal may be threatened from without our country or from within, and the dictum that eternal vigilance is the price of liberty applies as well in the one case as in the other.

To maintain law and order in our society is more than to preserve property or safeguard life. It is to maintain a social framework in which the good life may be lived; to free men from the threat of vicious cruelty of the criminally minded. Respect for government itself grows as governmental agencies succeed in this vital work of the preservation of freedom.

To-night the National Academy of Sciences presents the Marcellus Hartley Medal for great public service to John Edgar Hoover, Director of the Federal Bureau of Investigation of the United States Department of Justice. . . .

Hoover brought to this great agency of American law enforcement a high idealism, great organizing ability, and a trained mind. He insisted at once on freedom in making appointments to his staff from any political pressure, and rapidly raised to a high level the requirements in character and training for the personnel of the Bureau. Brains and character—not brawn—became the word. College graduates—not political castoffs—became his special agents. Specialized functions were organized and raised to a high efficiency. Through this organization the dignity and ability of a profession are being brought to a level consistent with its social importance. . . .

In spirit and performance the work of John Edgar Hoover has exemplified the scientific way of life. To the many formal expressions of appreciation which he has received we add to-night that of the National Academy of Sciences for great public service performed in a scientific manner and by the aid of science.

On receiving the medal, Mr. Hoover expressed his appreciation of the award and said in part:

The development of science in the field of crime detection has not been without its annoying interruptions. With the inauguration of the Technical Laboratory of the FBI in 1932 came ridicule and scorn. On more than one occasion our men have been ironically depicted as impractical young men pursuing criminals while clad in academic gowns carrying magnifying glasses.

The experiences of the past few years have demonstrated conclusively that science protects the innocent and convicts the guilty. Surely a record of over 95 per cent. convictions in all cases tried in court after investigation by Special Agents of the FBI is a tribute to the place of science in the world of law enforcement. There can be no question that we have been justified in investing the taxpayers' money in the equipping and maintenance of a Scientific Crime Detection Laboratory that is regarded as a model throughout the world, when over a period of years every dollar spent in the cost of operations of the FBI has resulted in a dividend of over six dollars for the taxpayers of America.

If the record of the Federal Bureau of Investigation means anything, it has proven that science is the greatest weapon next to intelligent, well-trained personnel that society possesses to cope with the criminal. No longer do courts question the validity of the qualified scientific expert.

Thus it is with pardonable pride that I accept the Public Welfare Medal of the National Academy of Sciences for and in behalf of the entire personnel of the organization that I have been proud to head for the past sixteen years; for ours is truly a "We" organization and not an "I" organization, and no finer recognition could be bestowed upon the FBI for its part in furthering science in the detection of crime than this award. May we regard the past as a period of introduction of science into the profession of law enforcement which will blossom and bear

fruit in the years to come in every community in America, in order that justice may ever remain triumphant.

On behalf of the Board of Trustees of the Charles Doolittle Walcott Fund of which he is a member, Dr. C. G. Abbot, secretary of the Smithsonian Institution, made the presentation address and referred to the purpose for which the medal and honorarium were primarily established, namely, to encourage work on Cambrian and Precambrian forms of life. In the words of Dr. Abbot:

The committee has unanimously recommended the award this year to Dr. A. H. Westergaard of the Swedish Geological Society of Stockholm, for his eminent researches on the stratigraphy and paleontology of the Cambrian formations of Sweden.

Westergaard's major work, published in 1922, "is a complete description of the trilobite species of which about 28 were new. The beds of Norway and Denmark are correlated with the Swedish formations." Now a man of 60 years, Westergaard is still active in the Cambrian field, having published frequently and regularly right up to the present time. His latest publication, in 1938, describes a deep boring through the Cambro-Silurian and File Haidar, in Gotland, and contains accounts of Lower and Middle Cambrian deposits therein and of the contained faunas.

In view of Dr. Westergaard's valuable contributions to both stratigraphy and paleontology of the Cambrian period, and his continued zeal in these investigations, the committee of award has much pleasure in recommending that the Charles Doolittle Walcott Medal and Honorarium be presented to him.

DR. A. H. WESTERGAARD

The medal and accompanying honorarium were received for Dr. Westergaard by the Minister of Sweden, the Honorable W. Bostrom, for transmission to him through diplomatic channels.

F. E. WRIGHT,
Home Secretary

THE IMPERIAL VALLEY EARTHQUAKE

ON May 18, the people of the United States were again reminded that there are regions within its borders where severe and even destructive earthquakes may be expected, and it was also demonstrated that after a severe earthquake there is no definite period of immunity. These are among the lessons of the Imperial Valley, California, earthquake occurring on that date, which, although not among the great earthquakes of the United States, stands perhaps fifth in property damage. Field observations by F. P. Ulrich, of the U. S. Coast and Geodetic Survey, who is in immediate charge of the seismological work of the survey in California and other western states, indicated that at Brawley, while perhaps 50 per cent. of the business buildings were damaged, newer residences suffered only slight damage. Local engineers estimate that the total damage may reach \$5,000,000. At Imperial, damage in the business district was very heavy. At El Centro, the damage was moderate and at Calexico, rather light. At Holtville, only

STRONG–MOTION SEISMOGRAPH RECORD OF THE IMPERIAL VALLEY EARTHQUAKE

OBTAINED BY THE COAST AND GEODETIC SURVEY AT EL CENTRO, CALIFORNIA. THIS TYPE OF INSTRUMENT OPERATES ONLY WHEN STRONG EARTHQUAKE MOTION STARTS IT. THE RECORD SHOWS THE ACCELERATION (SOMETIMES CALLED "FORCE") OF THE GROUND MOTION IN TWO HORIZONTAL DIRECTIONS AND THE VERTICAL. FROM TOP TO BOTTOM THE THREE TRACES SHOW MOTION IN THE VERTICAL, NORTH-SOUTH AND EAST-WEST DIRECTIONS, RESPECTIVELY.

a few chimneys and walls were thrown down.

One of the serious effects in this region, which depends upon irrigation, was damage to water supply. This included breaks in the canal on the Mexican side of the border and the collapse of the city water tank of 50,000 gallons at Holtville. Engineers are greatly interested in damage to the necessary structure related to water supply, including dams and embankments and also tanks, and the damage to these will be carefully studied.

Those interested in the construction of tanks have given much thought to the matter since the Long Beach earthquake of March 10, 1933. Professor A. C. Ruge, of the Massachusetts Institute of Technology, has studied the design of tanks to resist earthquake damage chiefly through studies of the behavior of a model which was tested on a shaking platform which reproduced the motions of the Long Beach earthquake as obtained from records of the Coast and Geodetic Survey. Undoubtedly, a new impetus will be given to such studies.

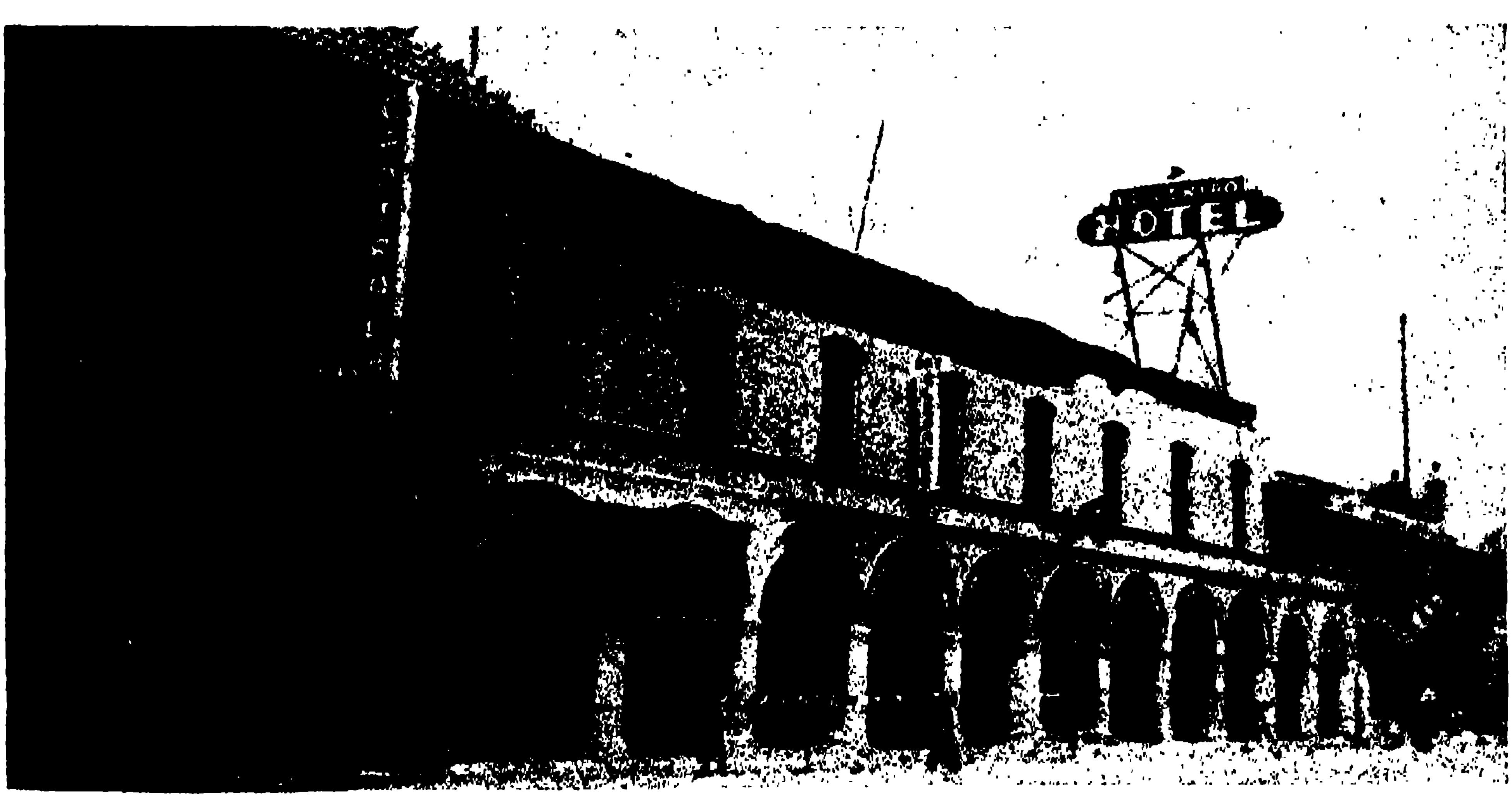
The geological conditions in the Imperial Valley region are an important factor. There are very deep sediments overlying the rock, and the San Andreas and other faults branching from it which can be well located further north are indicated in the fault maps by broken lines, since they can not be directly traced. In most of the earthquakes in this region the surface changes have been almost undetectable, but on this occasion there was a slip of 12 feet in the northwest-southeast direction at a place near Highway 98. The Coast and Geodetic Survey has executed triangulation and leveling in this region and these observations would have to be repeated in order to detect other changes which are not visible. It is expected that an instrumental study of the earthquake will be undertaken by the Seismological Laboratory of the California Institute of Technology at Pasadena.

Fortunately, an accelerograph for the

recording of strong earthquake motions which the Coast and Geodetic Survey had in operation at El Centro (at the Terminal Station of the Southern Sierra Power Company) gave an excellent record, which is reproduced in Fig. 1, and there were a number of records at other points in southern California. This record shows the highest acceleration which has yet been measured, but the record will have to be carefully analyzed before definite statements can be made. Strong-motion instruments were set in operation in both the San Diego and the Los Angeles regions. There are now 51 instruments in operation in California, four in Montana, one in Utah, four in Nevada and one in Panama Canal Zone. All but three (Lake Mead region, U. S. Bureau of Reclamation) are owned and operated by the Coast and Geodetic Survey, with considerable cooperation. With this distribution, recording is assured of the motions of practically all destructive earthquakes that may occur in California and in the other localities mentioned.

Some of these instruments have such a wide range that they are able to record the accelerations of the most severe earthquakes. That at El Centro, set up in 1932, was an earlier type and for a very short period the record was off the sheet, though from a practical view-point there is no serious loss of record. With a few exceptions the instruments are designed to give the acceleration, though the periods and duration of earth motions can be obtained from them directly and the displacement, or to-and-fro motion of the ground, by integration. Any or all of these elements may be concerned in destruction, and one of the valuable features of these records is that by a study of the destruction immediately after it occurs it may be related to the actual earth-movements. This has been possible only for the last seven years.

The violent motions shown in the record are in part due to the intensity of the earthquake but also in part to the fact that the surface of thick sediments is put into violent motion. The same phenomena were observed in the 1906 California earthquake and in the Mexican earthquake south of the Imperial Valley on December 30, 1934. There is a curious paradox in regard to these violent motions, in that while the actual motions of sediments are more violent, there seems to be a cushioning effect in the case



EARTHQUAKE DAMAGE TO HOTEL IN EL CENTRO IN CENTRAL CALIFORNIA

A MAN WAS KILLED WHEN THE UPPER PART OF THE BRICK WALL FELL INTO THE STREET.

FAULT JUST WEST OF ALAMO RIVER BRIDGE
ON HIGHWAY NO. 98. THE SHIFT WAS EIGHT FEET IN AN EAST-WEST DIRECTION AND THREE FEET VERTICALLY.

of strong buildings. This problem has not yet been solved by engineers and seismologists, but it has an important bearing on safety measures.

Most of the cities and towns are comparatively small and there are few tall buildings. The buildings that have chiefly suffered are not more than a few stories in height; therefore, it is a matter of great interest to the average citizen to find out what safety measures should be taken. It seems probable that application of the California code of building construction in reconstruction, both as to material and workmanship, will greatly reduce future damage. Proximity of weak and strong buildings accounts for much destruction in present-day earthquakes.

Reconstruction is closely related to the future probability of earthquakes. While prediction of earthquake in time and place is now impossible and likely to remain so, the seismic history of a region is a good guide to what may be expected. The first historic earthquake which may be ascribed to the Imperial Valley was in 1843. Then there were no others listed till 1903, though the Southern Pacific Railroad has traversed this region since the early 1880's and its personnel would have reported any earthquakes of importance. From 1903 to 1940 there have been fourteen destructive and near-destructive earthquakes, of which three were strong aftershocks. The principal occurrences were in 1915 and 1927 with serious destruction in a number of towns; and 1930 with strong local damage in Westmoreland and Brawley, in two distinct shocks. Some of the shocks mentioned were in Mexico but were near enough to cause damage. With such an earthquake record it is essential that provisions for resistance to earthquake damage should be made in the case of all reconstruction and new construction in this entire section of the country.

N. H. HECK

A PALEONTOLOGICAL EXPEDITION INTO THE SOUTH DAKOTA BADLANDS

A JOINT paleontological expedition of the National Geographic Society and the South Dakota State School of Mines will work in the Badlands of South Dakota during the coming summer in search of fossil remains of mammals, especially those of New World types of rhinoceros. The expedition, just announced by Dr. Gilbert Grosvenor, president of the National Geographic Society, will begin its field work early in June. Dr. Joseph P. Connolly, president of the School of

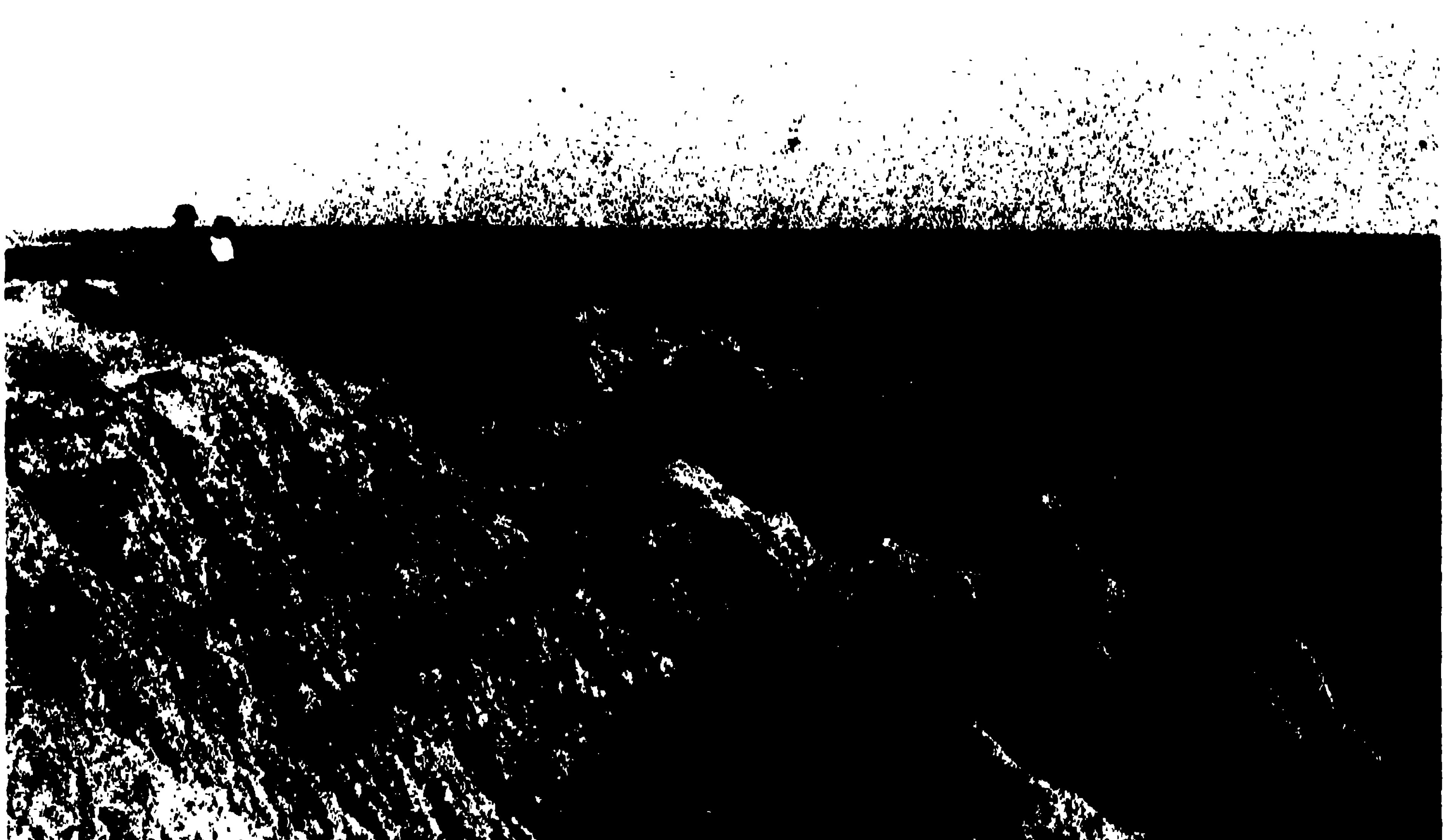
Mines, will be in charge, assisted by James D. Bump, curator of the museum of the school.

The excavations will be made in southwestern South Dakota in the fantastically eroded badlands area between the Cheyenne and White Rivers, southeast of Rapid City. Although it is expected that skeletal remains of numerous large and small mammals will be found, a special search will be made for fossil bones of titanothere (literally "giant beast"), other types of rhinoceros and protoceras. The titanothere was a sort of elephantine rhinoceros, the largest of them as much as nine feet high at the shoulder. Buried in the same beds of rock with these giants were much smaller rhinoceros-like creatures. Both these types of animals had relatives in the Old World.

The protoceras, as reconstructed, was an odd beast, remotely related to deer and antelope. The male, about the height of a sheep, had six horns or knobs on his head, one pair of them far down on his slender muzzle. Other unusual features were a pair of long slender tusks, rare among cud-chewing animals, front feet with four toes and hind feet with only two. No member of the protoceras family has been discovered outside of North America.

It is estimated that the beasts whose fossil remains the expedition hopes to find lived in the Badlands area, then a grass-covered region of rolling plains, about thirty million years ago. Through changes not entirely clear to geologists, large quantities of eroded materials and volcanic ash from an unknown source were deposited on the old grassy plains, covering skeletons of some of the creatures that inhabited them.

Erosion during the last ten thousand years or more, while creating the weird, deeply carved terrain of the Badlands, has exposed some of the buried bones and has disclosed the region to be a rich treasure house for paleontologists. Petrified skeletons of many types of vertebrate animals have been found there during the last three quarters of a century. But among these only a few complete



Photograph by National Geographic Society

A TYPICAL VIEW OF THE BADLANDS BETWEEN THE CHEYENNE AND WHITE RIVERS

Photograph by National Geographic Society
A PORTION OF THE SOUTH DAKOTA BADLANDS SOUTHEAST OF RAPID CITY

skeletons of titanothere, protoceras and small rhinoceroses have been recovered. The expedition's chief aim will be to bridge this gap in scientific knowledge of the region.

The South Dakota Badlands were relatively inaccessible until a decade ago. Within the past few years some of the most scenic and picturesque portions of the eroded area have been set aside by the United States Government as the Badlands National Monument. Excellent automobile roads have been built through the reservation. During the year 1939 visitors numbered 205,100, the greatest number to visit any National Monument west of the Mississippi River.

McFall Kerbey

RECENT PROGRESS IN THE STUDY OF BLOOD CLOTTING

Recent work on blood clotting has aroused the interest both of biologists and of practicing physicians. Present view-points are based on the older physiological studies, which, in turn, were a gradual outgrowth of the "vitalistic" concepts of olden days. The clotting process is known to occur in two main stages. The clot itself is formed in the second stage by the transformation of a soluble protein, fibrinogen, into an insoluble protein, fibrin. The fibrin clots out in the form of innumerable interlacing threads which, in the aggregate, give the clot its rigidity.

The transformation of fibrinogen into fibrin in the second place is brought about by a ferment-like substance known as fibrin ferment or thrombin. Thrombin does not occur as such in circulating blood, otherwise clots would form within the vessels. Blood does, however, contain a proferment known as prothrombin. It is during the first stage of clotting that this proferment is converted into thrombin.

One of the recent developments concerns the varying ability of the body to manufacture prothrombin. For one thing, we have been able to show in our

own laboratory in Iowa City that the liver is concerned in the process. When this organ is seriously diseased the prothrombin content of the blood falls to abnormally low levels, and the individual bleeds excessively, even from tiny cuts and scratches.

More important, still, is the discovery of a new "coagulation vitamin," vitamin K, which the body needs in order to manufacture adequate amounts of prothrombin. This vitamin was discovered more or less incidentally in the midst of dietary studies made ten years ago on chicks by Dam of Copenhagen. It was later shown by Dam and by Almquist of California and by their colleagues that the new vitamin is abundantly present in many green vegetables, notably in spinach and alfalfa. The vitamin was finally extracted and purified and the chemical nature determined through their efforts and those of Doisy and his colleagues of St. Louis. It was likewise shown that a score or more of compounds could be produced which possess biological activity similar to the naturally occurring material. Almost without exception the active compounds were derivatives of 1,4-naphthoquinone.

Recent work indicates that simple dietary deficiency is rarely sufficient to cause a serious lack of vitamin K in man. However, there are conditions in which this vitamin is not properly absorbed from the intestine. The chief condition is one in which the intestine fails to obtain the bile which normally passes through the bile ducts into the upper portion of the small intestine. Bile is important because it aids in the absorption of oily materials, including vitamin K. A lack of bile occurs whenever the main bile duct is obstructed by gall stones or by tumor growths, causing the familiar clinical picture of obstructive jaundice.

That patients with obstructive jaundice can be cured of their bleeding tendency by administration of vitamin K was first shown by Drs. Warner, Brinkhous and myself, and by Butt, Snell and Osterberg at the Mayo Clinic. Since these studies were made, three years ago, numerous confirmatory reports have appeared, and vitamin K is now used routinely by great numbers of medical practitioners. Incidentally, it has been shown that vitamin K may be of value in the treatment of certain types of hemorrhage which appear at times in young infants. Some workers have suggested the wisdom of giving the treatment routinely to newborn infants, or to the mothers prior to delivery.

A second development which promises to be of considerable importance involves the isolation and purification of the clotting ferment, thrombin. Dr. Walter H. Seegers in our laboratory has improved upon the older technics, and recently he has obtained thrombin of such potency that one part of it will cause 20,000 parts of blood to clot solidly within one or two seconds. This is vastly more rapid than the spontaneous variety of clotting, which normally requires five or ten minutes.

Preliminary tests on animals and on man indicate that purified thrombin may be of great value in controlling certain types of bleeding at operation or from accidental wounds. The bleeding from large vessels can be checked quite well with ligatures, but in the case of true "bleeders," the bleeding often continues for hours from innumerable tiny vessels, and it is in such cases that thrombin promises to be of benefit. Thrombin has not yet been prepared on a commercial scale, however, and it is evident that many months will elapse before adequate amounts of thrombin can be obtained for the large-scale tests which must precede any attempt to place the product on the market.

A third development which has received much attention is in connection with certain naturally occurring prod-

ucts which inhibit clot formation. Somewhat over twenty years ago Howell and Holt of Baltimore described one such inhibitor, which they spoke of as "heparin," because it could be obtained from the liver. Other factors which inhibit clotting have been studied recently, and the possibility exists that some of them may be the cause of certain types of bleeding which still defy precise analyses.

In the meantime, workers in Toronto have made much progress in their efforts to purify heparin, and Dr. C. A. Best of that city has proposed giving heparin intravenously to prevent or to check the clotting which sometimes occurs within vessels of the living patient. Quite recently, surgeons had removed such clots in well-selected cases, and have employed heparin to prevent the clot from reforming during the process of healing.

Despite the progress in various fields, much still remains to be done. It is evident that there are at least four or five fundamentally different types of bleeders. Vitamin K is of benefit only in one specific group. The other types must still be treated by transfusion, or possibly by thrombin. It is to be hoped that the fundamental technics of chemistry, applied in the laboratory and in the clinic, will bring as much enlightenment in the next few years as they have in the recent past.

H. P. SMITH, M.D.

CIVILIAN SCIENTISTS IN GOVERNMENT SERVICE

THERE were on November 1 a total of 41,912 civilian scientists in the employ of the Federal Government, each receiving an annual salary of at least $2,000, of whom 40,200 were males and 1,712 were females. There were, in addition, 17,615 representatives of other professions, such as accountants, architects, lawyers and librarians.

Of the scientists, the engineers were the most numerous, with a total of 17,702. The next largest group was the economists, with 6,300 males and 300 females. The physicians and dentists stand high with 2,650, of whom only 50 are women, followed closely in numbers by 2,000 veterinarians. If the word *scientist* has been interpreted rather more liberally in the foregoing than is customary, we may note that there were on the list 3,200 agriculturalists and botanists, 1,230 physical scientists and geologists, 1,335 chemists and metallurgists, 780 statisticians and mathematicians, 640 zoologists and naturalists and 1,015 entomologists and husbandmen. One of the interesting groups is the 445 reporters and editors, or one for every 94 scientists, even with the liberal interpretation of the term used above.

From one point of view, the large number of civilian scientists and technicians employed by the Federal Government is a measure of the support the government is giving scientific work. From another point of view, the large number of these employees raises an important question of long-range policy, because control inevitably lies with financial support. As illustrative, but as yet quite exceptional, we may cite the engineering reports on the Passamaquoddy electric project and the proposed canal across Florida, which were in direct contradiction to reports that had more than once been made by similar authorities before these became government projects. In view of the fact that in various parts of the world political authority now decides what shall be taught respecting questions of science and history, we may well inquire whether the long future will confirm our present high opinion of our system of politically controlled public schools. As the history of civilizations goes our experience in public education is yet very short.

F. R. M.

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WHY THE JAPANESE ISLANDS?

By Dr. BAILEY WILLIS
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THE snow on the summit of Fugi San slowly disappears as the summer advances and the peasant thanks the goddess for her bounty of abundant water for the rice fields. But were the snow to melt away in winter time there would be dismay instead of gratitude, for it might mean that Fuji San was awakening from her long slumber and her fires might spread destruction in the populous plains at her feet. Japan has often experienced such rude awakenings of volcanoes long dormant, while others have records of more or less frequent eruptions. When the volcanic fires are rekindled no man knows what terrific powers they may develop. Gradually, during weeks or months, the interior of the mountain heats up. Eventually hot gases and a lava stream pour out or an explosion occurs. The activity continues for a time and then dies away, leaving the steaming cone to relapse into a dormant state. The amount of energy expended is enormous, extraordinary as it seems to us; but it is a normal incident, nothing more, in the earth's long history. What is this persistent source of heat, which throughout all geologic time has been competent to produce such outbursts?

That question was easily answered when we thought, as we used to, that the molten interior of the globe was covered by a thin crust. It might be expected to escape through cracks; the wonder was there were not more eruptions. But now that we know the solid mantle over the core to be at least 1,800 miles thick, the facile explanation no longer works if the mantle is solid and crystalline, not glassy.

Speculation next framed hypotheses upon the assumption that volcanoes originate in the rigid crust, above the elastic, plastic mantle. A number of conditions which might produce a local concentration of heat within a few miles of the surface were considered by different theorists. Might water penetrate the rocky crust to a depth at which, on meeting rocks nearly hot enough to melt or molten, it might cause them to melt by lowering the melting temperature of the minerals. Or, assuming that at a moderate depth there are rocks which are restrained from melting only by great load, could the load be lightened in some way so that they would be able to melt? Or could a buried mass of rock, at high temperature, be crushed in such a manner that the heat of compression and friction would melt it?

While each of these suggestions rests upon a possible physical reaction, no one of them corresponds to the actual conditions of volcanic activity and its distribution. Each one fails when critically faced by the known facts.[1]

[1] Chamberlin and Salisbury, "Geology," Vol. 1, pp. 624 *et sequi.*

One of the most striking phenomena connected with vulcanism is the enormous volume of gas and steam emitted during eruptions. Advocates of a superficial origin regard the gases, and more especially the steam, as due to penetration of surface waters, *i.e.*, as secondary by-products. Those who incline to a deep-seated origin look upon them, and more especially the gases, as original constituents of the earth's mass; *i.e.*, as primary elements. The original nature of the gases, which are observed to burn as they burst from the lava, was a critical, unknown fact. Their burned products, such as steam and sulfur dioxide, could not be distinguished from atmospheric constituents. To know if they were primary we must catch them before they reached the air. And this could be done only at the surface of a lava lake, where the temperature is 2,000 degrees Fahrenheit. Difficult as that may seem, it was accomplished by A. L. Day and E. S. Shepherd in May, 1912, during a descent into the Firepit of Kilauea, during an active eruption. They were lowered over the vertical wall to the edge of the thin crust that covered the bubbling surface and they succeeded in drawing off original gases from within a lava cone. They were chiefly hydrogen and sulfur, which must have been oxidized instantly had they come into contact with the air. They therefore obviously had come from a source below the depth to which air or water could penetrate.[2]

The volume of gases which thus escapes and burns at the surface of the lava is but a small fraction of the total amount of steam and gas emitted. The larger part has been burned in rising through the upper few miles of rock, where oxygen is available, and burning in confined spaces it has produced the heat of a blowpipe. That is quite enough to melt rock. Thus it would produce lava.

[2] Day and Shepherd, *Bull. Geol. Soc. America*, 24: 573–606, 1913.

We are brought back to the consideration of a relatively superficial origin for some volcanic lavas, provided there be a source from which primary, so-called juvenile gases are supplied. That source can only be some spot in the lower part of the outer crust or in the upper part of the underlying mantle. And it must be a heated spot, a heated body of rock, because gases, although contained in all igneous rocks, remain fixed in equilibrium unless the temperature rises. Thus a volcanic eruption means that a mass of rock, situated at considerable depth, has been heated to the melting and boiling point, at which it expels gas; and the escape of the gases leaves it relatively cool and inert for a shorter or longer period.

The great variations in activity which are characteristic of volcanoes are thus traced to similar changes in temperature at a depth below the reach of any superficial reaction. The cause of changes is a condition of the interior, in a zone where theory assumes relatively constant temperature. What is the source of the variable heat energy? It probably is transmutation of atoms, especially radioactive generation of heat: appropriate in character, probable in that general zone, and adequate in amount. No other source that so fully meets all the requirements is known.

Reviewing these speculations we find that we have returned to the original inference, namely, that volcanic energy springs from a molten mass within the globe; but, whereas that mass was formerly supposed to comprise all the interior beneath a thin crust or to be represented by residual bubbles in the cooling sphere, it may now be regarded as a local hot body, which is chiefly heated by atomic (radioactive) disintegration. Vulcanism in any region may be thought to have been initiated when the molten body, rising from the depths, so nearly

reached the outer crust that gases might ascend to the zone of oxidation. The effect of their very high temperature plus the heat produced by their partial combustion is to melt the rocks they penetrate and so to form lava, which erupts, it may be quietly or explosively. In the meantime the deeply buried, heated body has lost its hottest constituents and subsides to a simmering state or becomes solid, though near the melting temperature. Volcanic activity becomes dormant or apparently extinct. But if the temperature of the source is again raised to the melting and boiling stage, the processes of vulcanism are revived. The source of the heat is in all probability that to which astronomers attribute the energy of the stars, the disintegrating atom.

The Japanese Archipelago is studded with groups of volcanoes. If the preceding picture of the origin of volcanoes be correct, we may reasonably think that there are hot spots beneath the islands or closely adjacent to them, but at some depth, presumably 25 to 50 miles or deeper. The inference seems good, but it is suggested by one line of evidence only. Are there any independent approaches? We might explore the heat-history of the islands, as it is recorded in the occurrences of volcanic and other igneous rocks.

In Japan there are active volcanoes, dormant volcanoes and extinct volcanoes. Among the latter are some which were high cones, but they have been eroded and their roots are exposed. They are relatively old, though geologically young. In general, volcanoes which may still be identified are not older than the Pleistocene (Glacial) period, though they may go back into the preceding Pliocene period. None has survived from the next preceding, the Miocene period, although lava flows attributable to volcanoes occur interbedded with sediments of that age. That carries us back twenty to thirty million years. Even more significant than the volcanic rocks are those which have risen forcibly from below in a molten state and have penetrated fissures in the outer crust. These intrusives, as they are called, may have been feeders of volcanoes, but they at least intruded the outer crust and there cooled, without reaching the surface. They are then regarded as branches of the deep-seated molten body and, especially when they consist of granite or related rocks, as having been part of that molten body or "magma" itself. Having solidified beneath the surface they have been pushed up and the covering rocks have been eroded. It generally has taken more than twenty million years to uncover them and they often date from very much older times.

The preceding explanation applies generally, in many parts of the world. In Japan there are igneous rocks of various kinds, which demonstrate the occurrence of hot spots beneath the islands during the last sixty million years and more. Not that any spot has always been hot enough to yield melted rock or to boil and give off gases continuously. The process is intermittent, the reheating very gradual, the intervals between epochs of eruptive activity have been of a duration of millions of years. But from the volcanoes of to-day back through the ages to the time when the great masses of granite which form so large a part of the islands were uptruded the sequence of heating, melting and attendant effects has been repeated in the terrestrial crucibles beneath the Archipelago.

The source of the heat energy, which accumulated until it caused melting, was dissipated in eruptions and attendant reactions, yet re-accumulated to produce later molten bodies, is involved in speculation and is attributed to different con-

ditions by geologists of diverse minds and experiences. Professor Daly of Harvard has listed a dozen ideas,[3] among which the speculative mind may wander seeking some fruitful thought. He who would distinguish truth from fancy should be guided by the discoveries of modern physics. The working hypothesis with which we here proceed to explore assumes the presence of radioactive minerals and recurrent heating by atomic bombardment, as has been stated.[4]

The effect of the process has been to build up the ridges which constitute the Japanese islands by the rise of molten rock masses from beneath the outer crust. Some of the bodies cooled beneath the surface and are known as intrusive, plutonic rocks; others have been remelted and have been erupted as volcanic rocks. The cold masses have been pushed up and worn down, exposing the once covered plutonics and forming sediments of various ages.

Recognizing that the islands have been thus built up of masses from many different sources, we may next examine the Archipelago to ascertain how the various parts are distributed and related to one another. It is as if we were looking at any building and inquiring how it was put together or what was its structure. What, then, is the structure of the Japanese Archipelago?

As may be seen on any map of Asia, the main Japanese island, Honshu, has the form of a curve, an arc, which reaches from the northern island, Hokkaido, to the southern one, Kyushu. Closer inspection, especially with reference to the relations to adjacent submarine basins, shows that the main island is not simple, but really consists of two separate arcs and a central massive body (See map).

[3] "Igneous Rocks and the Depths of the Earth," Chapter X, 1933.

[4] Bailey Willis, *Bull. Geol. Soc. of America*, Vol. 49, 1938.

It is necessary here to introduce a generalization regarding the structure of the earth's crust. The arc is a very common form of its features. It is especially characteristic of mountain ranges. And where two arcs meet, there is usually a massive, irregular bunch or knot of more or less mountainous character. Designating the arcs as *arcs,* we may refer to the knots as *nodes.* And we may say that the crust of the earth presents on its surface many arcs and nodes and the basins which they define. Perhaps we may learn why this is so, but however little we may understand of the constructive processes it is clear that the Archipelago comprises a group of typical structures of the crust of the globe.

Enumerating the parts of the group we may distinguish:

Hokkaido node, at the junction of the Karafuto and Kurile arcs and connecting with the Honshu arc.

Honshu arc, extending from the Hokkaido node to the Gifu node, the central body of the main island.

Gifu node, at the junction of the Honshu arc with the complex structure comprising the Tsushima and Shikoku arcs.

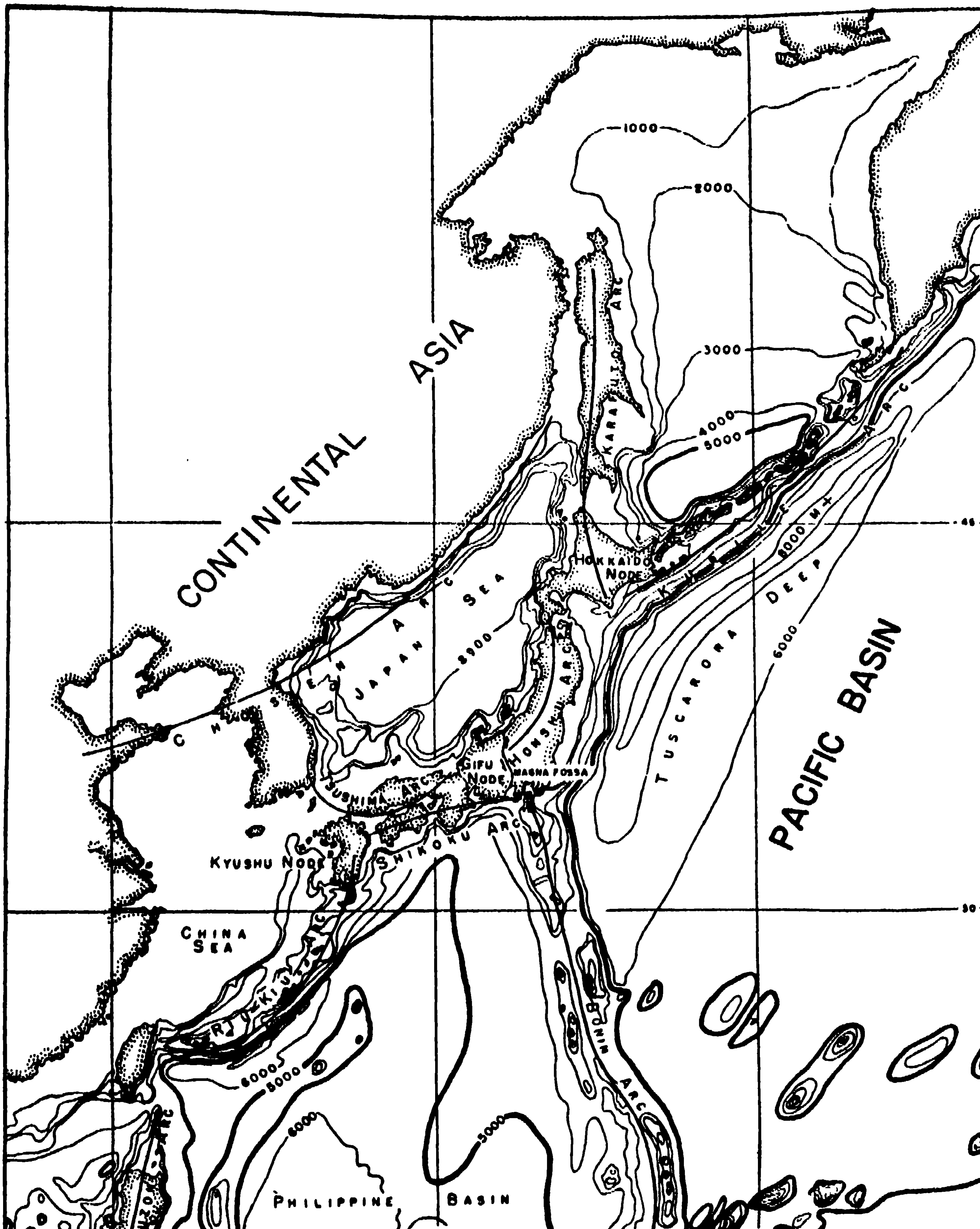
Tsushima and *Shikoku* arcs, which lie closely pressed together, but are convex in opposite directions.

Kyushu node, at the meeting of the Tsushima and Shikoku arcs with the Riu-Kiu arc.

Riu-Kiu arc, extending to Formosa.

Curiously enough and contrary to general assumption, the island of Formosa or Taiwan is not a part of the arcuate structure, but consists of the sediments of an ancient delta, probably that of the ancestor of the Yangtze River, which have been folded up into a mountain range. Thus Formosa occupies a gap in the succession of arcs that borders the Asiatic continent, which is continued southward by the Luzon arc and others of the Philippines.

These garlands of curving islands which drape the eastern coast of Asia enclose between themselves and the con-



JAPANESE ARCHIPELAGO

ITS ARCS AND NODES WITH ADJACENT BASINS.

tinent large water bodies, that in part occupy deep basins, in part submerge the continental margin. We are here concerned only with those which are related to the Japanese arcs. The most conspicuous of these on the map is the Japan sea, covering an oval that is roughly 400 miles across. Its depth over

a considerable expanse is at least 1,500 fathoms or that of the shallower oceanic depressions.

Another submerged area is that of the Yellow or Chinese Sea, which is bounded by the eastern coast of China, Korea and the southern Japanese islands. Though similar in area it contrasts strikingly with the Japan Sea in depth, being very shallow. The sounding line shows only 20 to 40 fathoms over most of its expanse. It is clearly a submerged part of the continental platform. And yet, just inside of the Riu-Kiu Island arc, there is a trough, which reaches depths of more than 1,000 fathoms and may be regarded as having been part of the oceanic basin.

Thus the Japanese ridge has risen through the bottom of the Pacific.

The so-called basin of the Pacific Ocean is not a single basin. It should not surprise us that the waters fill many hollows, if we remember that they cover nearly half the surface of the globe. The Pacific is often discussed as a unit in form, origin and history. It is far from being so simple in any respect. Abreast of Japan are two large basins, separated from one another by the ridge of the Bonin arc, which extends southerly from the Gifu node. To the west of it is the great sea which is called the Basin of the Philippines because it stretches down past the eastern islands of that group. It is 1,200 miles across and is of oceanic depth, 3,000 fathoms and more. Eastward and northeastward from the Bonin ridge extends the North Pacific, where soundings are too few to afford data for definition of minor areas.

The exposed points on the Bonin ridge are volcanoes. Hence we may infer that the ridge resembles the Japanese arcs in being of eruptive origin. The rock masses which form the ridge have also come up through the ocean bottom. On the south it adjoins other arcs that appear as the islands of Oceanica and like it have risen through the ocean bed. Is there not some condition which has determined this arrangement of eruptions in a pattern of arcs? Is it some peculiarity of the oceanic regions? Apparently not, for the same pattern is characteristic of the curving mountain ranges on the continents. Is it some manner of growth of segments of the earth's crust, like the plates of armor on a dinosaur? And if so, do the eruptions define the margins of discs that extend over hot spots?

This last is the best guess that I can now offer. I think that a hot spot or a group of hot spots may be from one to several hundred miles in diameter and hotter in some parts, cooler in others; that such an area has had a long history of development, of successive eruptions, which have built up the disc in the outer crust; that the disc has assumed a rounded form, such as is characteristic of molten bodies; that the main body has been cemented by repeated intrusions and has been rendered relatively impenetrable, so that later eruptives have migrated outward, under it, toward the margins, where they may solidify beneath the surface or remain hot enough to constitute local hot spots and give off gases to heat volcanoes.

We might proceed to test this speculation by a review of the eruptive history of the crust of the earth, but that would lead us far from Japan. Accepting it as a fair guess we may examine the basins around the Japanese Archipelago to see what relations they bear toward the island arcs. The Japan Sea fills a basin west and north of the Honshu and Tsushima-Shikoku arcs and is separated by the main island from the two larger basins of the Pacific, which are divided by the Bonin arc. The ridges of the Archipelago obviously constitute the rims of the basins, between which they rise

as high mountain chains. Their general altitude above the flat bottoms of the basins is 12 to 15 thousand feet. They consist of granitic and other igneous rocks, together with sediments which have been folded and crushed. In every respect of constitution and dynamic history they are mountain chains and may be compared with the ranges which encircle the continental basins of Asia. One can hardly doubt that they are results of the same forces and processes.

But though the mountain ranges of Japan resemble mountain ranges in general, the bases from which they rise are different in that they are submarine, not continental. The rock bottoms of oceanic hollows are unlike the plateaus of continents chiefly in the minerals of which they are composed. It is the difference that exists between basaltic and granitic rocks, between two slags, as it were, the one (basalt) containing more iron and magnesia with less silica in proportion, the other reversing these relations. How this difference originated is a problem involving the chemical and physical reactions in the furnaces beneath the outer crust, where melting and crystallization occur at varying temperatures and pressures, under conditions that we can not reach in laboratory experiments, though we may approach them. Our knowledge and its limitations are well stated by Bowen,[5] but however they may have been produced there is no doubt of the separation of the great volumes of granite as continents from the much greater volumes of basalt that constitute the ocean beds.

Now the ocean beds are exceedingly flat; no plate or saucer is as shallow or as smooth as the bottom of an oceanic basin. Continents by contrast are rugged, but we do find in them large areas which are flat, some of them because they were built that way; and they consist of flows of basalt. They are the areas of the so-called "plateau basalts." Just to cite one as an example, the Columbia and Snake River basalt plateaus of the northwestern United States have an area of some 300,000 square miles and when erupted were very flat. The lava lies in thin sheets, as it spread out after rising through fissures, piling up sheet upon sheet to a thickness of a mile or more. Evidently there was beneath that region a hot spot (or several hot spots, since the eruptions were not all of one age), in which the basalt melted or separated from a parent melt and from which it rose. This form of eruption differs from the volcanic, in which basalts build broad domes, like Mauna Loa in the Hawaiian Islands, and is known as fissure eruption. A third basin, that of the Sea of Japan, was formerly covered directly by waters of the Pacific, since the oldest identified rocks of Honshu are marine (Paleozoic) sediments; but even so it may have been formed over an independent hot spot, and considering its size it probably was. Its area is approximately 250,000 square miles and thus compares with those of the "plateau basalts." The uplift of the mountain chain that is represented by Hokkaido, Honshu and Kyushu has in more recent times separated it from the Pacific Basin.

Removing the waters from the seas we now have an idea of basins and mountain ranges and may see the Japanese Archipelago rising from the ocean beds as the mountain chains of Asia rise from the plateaus. In both regions, in the oceanic as in the continental, high ridges form the margins of rounded, flat areas; and in both, the elevated margins are crushed in such a way that it is evident they have been pushed up. Crushed is, perhaps, not the right word, for it suggests a disorderly mass of fragments; a mountain range is not a disorderly

[5] "The Evolution of Igneous Rocks," Chapter XVII, 1928.

mass; it consists of various rock masses, which assembled originally in a definite order and which have been moved into another, but still orderly arrangement. What looks like disorder, where rocks of different ages and different kinds occur seemingly jumbled together, is found to be orderly when we apply the laws of mechanics and deduce the action of the forces that have caused the rearrangement.

Perhaps this requires a little explanation. Let us recall an experiment made way back in 1797 by Sir James Hall of Scotland and described by him in 1812. He placed a thick pile of cloth on a table, loaded it with a heavy door, and then applied pressure to the pile of cloth, horizontally, so that he forced it into folds. Thus, said he, have the strata of rock, which may be observed on the coast, been folded up. He thought they must have been soft when folded, but in that he was mistaken. The hardest sandstones and limestones may be bent, provided they are so loaded that the rock can not break apart. In mountains we find piles of strata thousands of feet thick, originally laid down as flat as the sea bottom, the oldest at the bottom of the pile, but now folded, forming arches and troughs that are parts of mountains or mountain chains. We also find that the rock masses, particularly the massive, unstratified masses, have been sliced by pressure, after the manner which in mechanics is called shearing. They then appear cut into blocks by two sets of parting planes, and not infrequently the blocks are pushed past each other.

The attentive reader may have realized that the pile of cloth, when forced into folds by Sir James, had to slide over the table; and, if he continued pushing after it had folded up closely, it would move forward as a whole. The same displacement happens when a mountain range is pushed up. Whenever it becomes so rigid that it can more easily slide as a whole than fold or shear internally, then it advances. The Rocky Mountains in western Montana have thus been pushed out over the Plains at least seven miles, as may be seen in Chief Mountain, and similar displacements amounting to as as much as twenty or more miles are known in various parts of the world. But the bottom on which the mountain mass moves is not horizontal, as the table was, it is inclined, and the deeper roots of the range ride up on it, pushing out over more superficial, younger rock formations.

To illustrate: In south, central Chile the port of La Concepcion is on the coast and the town of Chillán is at the foot of the Andes, a hundred miles inland. On January 25, 1939, both cities experienced a severe earthquake, which to a less degree shook the intervening mountain country. The shock was due to a slip on the bottom of the coast ranges, which are being shoved eastward. A very similar, wide-spread disturbance occurred in north central Chile on November 10, 1922, and the nature of the quake-producing movements was studied in some detail. The conditions differ from those in California in that the elastic vibrations are started from a very gently inclined surface of dislocation and affect a large area severely, whereas in California they originate on a vertical plane and are strong only along the narrow strip where it appears at the ground surface.[6] In both regions the earthquakes are due to movements of mountain blocks on planes of dislocation, so-called faults, but in the Chilean type the fault is a *thrust* or *overthrust*, whereas the Californian is a *vertical shear* with *horizontal displacement*, which may be attributed to a rotational movement. Instead of being pushed up an incline, the mountain block

[6] Bailey Willis, *Carnegie Institution of Washington, Publication* No. 382, 1929, page 74.

in the later case turns, like a man in a dense crowd. We will find both types of faults in Japan.

Japanese geologists have during the past half century surveyed their country in detail. They have published excellent maps and have been generous in describing the facts to the foreign colleague, who could not read Japanese. My personal obligation to them is great. The geology of the islands has also been described and interpreted by foreign geologists, especially by the German authorities, Edmund Naumann, Ferdinand von Richthofen and Eduard Suess, and European thought has influenced the reasoning of Japanese students, who have studied in France, Germany or Switzerland. The several attempts to account for the peculiar form and position of the Archipelago have been excellently summarized by Professor Hisakatsu Yabe, of Sendai, who clearly points out differences of opinion and suggests modified views.[7]

All these discussions appear to share a defect that is common to many geologic speculations in that they fail to discover any force adequate to perform the stupendous work of mountain-building or to explain how the observed structures can have been produced, consistently with the principles of mechanics that govern the processes of rock deformation. We may, perhaps, frame a more workable hypothesis if we first postulate the action of a known, competent force and then show that it can be harnessed in such fashion that it will cause (or has caused) the demonstrable displacements of the crust.

Let the assumed force be that which resides in crystal minerals, where it holds the atoms to their stable relations.

Let there be disturbance of those stable relations by heating in the presence of chemically active liquids and gases; the heat being attributed to radioactive degeneration of atoms by those slow processes that generate heat energy.

Let us assume that the generation of heat by radioactive processes proceeds in a limited mass of rock situated beneath the outer crust (at depths not less than 25 miles or more) and that it there produces a molten bubble, which grows slowly and is encompassed on all sides by solid, crystalline rock.

Let the development of these conditions endure for some millions of years.

Let it be understood that crystals tend to adjust themselves to their environment by such changes of constitution and form as may produce a mineral or minerals better balanced under changing conditions of temperature and pressures. In other words, they undergo metamorphism. And, furthermore, when the change involves an increase of volume or the transformation of granular forms into elongated ones, then the growth exerts a force that may become equal to the crushing strength of the crystal.

Let it be further understood that the law of least resistance directs the growth of any crystal which is elongating in such manner that it must grow longer in the plane at right angles to the greatest pressure and in the direction of the least.

Let us accept the following conclusion: At the assumed depth of 25 or more miles the weight of superincumbent rock exceeds the crushing strength of the rock on which it rests. It is supported, therefore, only in part by that strength. The stability depends upon the lateral support or horizontal pressure of any mass against the adjacent one. But since the strength holds up some of the weight, the horizontal pressure, under conditions of stability, must be less than the vertical pressure. Consequently, if any crystal in that environment undergoes a change of form involving elongation, the direc-

[7] H. Yabe, in *Science Reports of the Tohoku Imperial University*, Sendai, Japan, Second Series (Geology), Vol. IV, pp. 70–104, 1915–1918.

tion in which it must grow, as determined by the law of least resistance, will lie in a horizontal plane; and in that plane it will be toward the weakest side.

From these considerations we may deduce a force which would be the resultant of an infinite number of crystal growths and which would exert a pressure in a definite, radial direction. Each atomic adjustment would exert a stress equal to the crushing strength of the mineral and the sum of any number of of them, acting in unison, would exceed the crushing strength of opposing rock. The latter must, therefore, be displaced. The action might become effective within the expanding disc or it might push out the surrounding frame. Since the increase of any dimension of a crystal undergoing metamorphic change may amount to two or several times its original length, the sum of elongations in a layer ten to one hundred or more miles across may attain the proportions reached by displacements observed in mountain ranges.

These are the assumptions and the reasoning of the hypothesis known as metamorphic orogeny, or mountain building, through recrystallization. How may it stand the test of explaining the structure of the Japanese Archipelago?

The mountain ranges of Japan are young, as is shown by the sharply incised canyons and valleys, which characterize the scenery of the uplifted blocks. They are indeed growing, being pushed up or turned by unbalanced pressures, as is demonstrated by the frequent elastic jumps that we call earthquakes. There are also many volcanoes, whose activity, as we have seen, may be attributed largely to hot gases rising from molten bodies. Thus the mountain-building pressure appears at the present time to be contemporaneous with the existence of hot spots in the same general part of the earth's crust. This relation has existed for some twenty million years or more, for the process of uplift and the volcanic activity may be traced in mountain forms, in sediments and in lavas back to the Miocene or middle Tertiary age, which is that far back. It is a long time and we may not assume that any terrestrial process has progressed steadily or continuously throughout the ages; but heat and pressure have been actively developed and dissipated in the one great structure, the Japanese Island arcs, during the last twenty million years.

Nor was this the beginning. The same activities have gone on side by side or in the relation of cause and effect since at least one hundred million years ago. The earliest event that has been identified in rocks now exposed at the surface was the intrusion of bodies of granite into the outercrust. They were uptruded from hot spots, which had presumably been heating up during a preceding age. Beginning in the Lower Cretaceous the intrusions arrived near the surface from time to time in a succession that continued through the thirty million years of Upper Cretaceous time and into the Eocene or early Tertiary. If the entire mass of all the granite bodies was originally molten before the first uptrusions began, then the successive intrusions may have been practically continuous. But that is improbable. It is theoretically more reasonable and also more in accord with observed relations to infer that the hot spots heated up gradually, lost the molten body when it became large enough to rise, and were reheated by their remaining radioactive elements. The process was intermittent. During the intervals sediments accumulated in basins and troughs on the surface and they, together with the intruded granite bodies, were compressed during repeated mountain-building episodes. The details of the prolonged sequence of events have not yet been deciphered and may never

be entirely, for the folding and shearing produced during any one orogenic movement becomes obscured by the next.

However simple or complex the history may eventually prove to have been, the general fact is that melting, intrusion and mountain-building are the activities by which the Japanese Archipelago has been constructed during the last hundred million years.

Pursuing our inquiry into the relation between hot spots and the sources or centers of pressure, we may try to place them. If on independent evidence they should be found to have originated in the same parts of the crust, the inference of a causal relation would be strengthened. There are two questions: Where did the granitic intrusions come from? and in what direction, from what region were the pressures exerted?

Regarding the granites the evidence of origin is most apparent in southwestern Japan and southern Korea. Granite bodies are numerous in the Tsushima arc and in the adjacent part of the peninsula, and they are chiefly of Cretaceous and early Tertiary ages. The zone of intrusions surrounds the southwestern lobe of the Tsushima Basin, a part of the basin of the Sea of Japan. The position may be an accident, but if, as seems logical, there is a reason for it we may infer that the arc, so far as it extends, defines the outer rim of the disc and that the paths of the intrusions in rising to the surface were governed by the form of the disc. The direction of the paths in approaching the surface was probably nearly vertical, but there is good reason to think that the molten rock followed lines of least resistance along the under side of the disc and up inclined shearing planes, before it turned more directly upward. Its source then should be located under the adjoining section of the Tsushima Basin.

The orogenic pressure which has repeatedly folded the sedimentary rocks of southwestern Japan and sheared the massive granites has acted consistently in a north-south direction. The rocks of the Tsushima arc are most intensely crushed, displaced in large masses and pushed over, one sheared-off sheet upon another. The whole arc is pushed southward upon the Shikoku arc and one of the great features of the structure of Japan is the so-called "Median Line," an overthrust of older rocks upon the Cretaceous, throughout the stretch from western Kyushu to the Gifu node. The push carried the northern sheet over the southern mass.

We may infer that the source of pressure was in the Tsushima lobe of the Japan Sea disc, over the probable source of the molten granites.

The case for the Honshu arc is very similar, but it introduces also another line of reasoning, of peculiar interest.

Granites in the Honshu arc occur chiefly in two zones, an eastern or outer, and a western or inner zone. Those of the outer belt are assigned to the Lower Cretaceous age; those of the inner may in part be of the same general antiquity, but may include some of later, possibly Tertiary date. Whatever their periods, there is nothing in their distribution to indicate their source, as there is around the Tsushima lobe. They may have come up directly or from under either the Japan Sea disc or the Pacific Basin. There is, however, a suggestion.

Upon the Pacific side the ocean is exceedingly deep. The trough of the Tuscarora Deep sinks a thousand fathoms below the general level of the nearby ocean bottom, to something over 4,250 fathoms. It stretches from abreast of Honshu northeasterly past the Kurile Islands and is characteristically long and narrow. Its form distinguishes it from the oceanic basins, which are typically broad and relatively shallow. Else-

where I have called attention to this difference,[8] and I attributed the subsidence of a narrow strip of the crust, in a region where there is evidence of igneous activity, to the collapse of a portion of the wall of a magma reservoir. The wall would stand so long as it was supported by the hydrostatic pressure of the molten volume, but it would slip inward at the base and sink down if that volume were reduced by eruptions. At the surface the effect would be to develop a trough, due to subsidence. The Tuscarora Deep bears the appropriate relations to a region of igneous activity and the inference regarding its origin accords with all known facts and with the principles of mechanics that should govern such a failure of the crust. We must, however, note a caution. The Tuscarora Deep is as young as the mountain ranges of Japan, to judge by the fact that it has not been filled with sediment. If it was initiated during the uptrusion of the Lower Cretaceous granites of eastern Honshu, it must have been deepened during the later, Tertiary eruptions. Any inference we may draw from it is, therefore, restricted to that relatively recent period.

If the Tuscarora Deep be due to collapse of the wall of a magma basin, the basin should lie to that side of it where the eruptions have occurred, in this case toward the northwest. And, since the Tertiary granitic intrusions and eruptions of rhyolitic, dacitic and andesitic rocks have occurred extensively in the western, inner zone, its locus should be sought under that side or under the adjacent area of the Japan Sea Basin.

As regards the direction and effect of orogenic pressure in the Honshu arc, we have an interesting study of the shortening of Tertiary strata, a map by Yanosuke Otuka, which shows that along lines radial to the arc the compression has amounted to as much as 8 or 10 per cent. and locally even to 34 per cent. of the original width. That is to say, any section which was originally 100 miles wide has been reduced to 90 miles or less by orogenic pressure. The stress acted from the Japan Sea Basin outward, toward the southeast, that is from the inferred locus of the hot spot.

We have still to consider the Gifu node, especially with reference to the displacements it may have suffered. It is a massive block of Paleozoic sedimentaries, which have been metamorphosed by very large intrusions of Lower Cretaceous granites and other igneous rocks. It is roughly a hundred miles square. The southeastern and southwestern corners are traversed by great faults, which have the character of fractures due to twisting, as if the mass had been turned in a clamp. And its eastern boundary is a fault zone of marked displacement, known as the Fossa Magna of Japan.

The Fossa Magna is a crushed zone, which runs across Japan, in a north-south direction between the Honshu arc and the Gifu node (see map). Known since more than fifty years ago, it has been discussed by all students of the geologic structure. Its true character becomes apparent when it is recognized that the general movement along it has been a slipping of the western block, the Gifu node, past and eastern. This is shown by the horizontal striations, where one mass has scored the face of another, and the displacement has been southward on the western side. There are, of course, many minor, though in themselves large, structures, both of folds and faults, which are due to pressure of the great twisting block against its neighbors, and the attempt to force these local developments into some theoretical mold of Asiatic mountain systems has resulted in unfortunate controversies. But the rota-

[8] *Carnegie Institution of Washington, Publication* No. 470, page 183, 1936.

tion of the great block of the Gifu node in a clockwise direction is a fact.

The direction of stresses, which might produce this rotation, should be directed diagonally to the Fossa Magna, toward the southeast, and they would originate in the area of the Tsushima lobe of the Japan Sea Basin.

Thus the examination of the three sections of the Archipelago, the Tsushima-Shikoku arcs, the Gifu node and the Honshu arc, leads us along various lines of evidence to the conclusion that the southern and southeastern parts of the Japan Sea disc have been the loci of hot spots and also the sources of orogenic pressures, both activities having been effective from time to time during the past one hundred million years.

Heat and pressure react upon one another and cooperate to produce a number of geologic phenomena in a variety of ways. Their reactions form the subject of many theories. Here we have a situation, however, in which the result of their action upon crystalline rocks, underlying a heavy load, over a heating mass, throughout an extensive region, during millions of years, can not have failed to cause recrystallization of the type which is characteristic of the "Archean" terranes of Canada and British Columbia, as well as of other countries where very old rocks are extensively exposed. Being so old, the gneisses and schists have been very deeply eroded and their structures may be observed. The rocks consist of flattened, elongated crystals, lying in horizontal or gently inclined attitudes. They have been recrystallized from igneous rocks of original granular texture and the change of form has been accompanied by expansion with great force, as may be seen in the roots of the mountain ranges that once rose along their margins.

Is it not reasonable to infer that the mountain chain which constitutes the Japanese Archipelago is similarly an effect of the heating up of hot spots and the consequent metamorphism of the overlying crust in the region of the southern Tsushima Basin?

If that question meets with an affirmative, even though provisional answer, are we justified in extending the inference to other regions, where mountain arcs border plateaus that consist of successive igneous intrusions to continental Asia, for instance, as suggested in "Growth of Asia" and "Wrinkles of Asia?"[9]

[9] SCIENTIFIC MONTHLY, June and November, 1939.

GEOLOGIC DATING OF HUMAN EVOLUTION IN ASIA

By Dr. HELLMUT DE TERRA

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LATELY we have received new and abundant information on Fossil Man in Asia, which should be interpreted in the light of Pleistocene geology in order to approach a solution of the problem of dating the extinct races of Man. The new skulls and skull fragments of *Pithecanthropus* found recently in Java, the many fossil remains of *Sinanthropus,* the Peking Man, unearthed from a limestone fissure near Peking, and the many thousands of stone tools collected from the Siwalik Hills in India down to the Dutch East Indies, all these new finds make possible a new approach toward the problem of human origins in Asia. Above all other considerations stands the necessity of establishing a chronologic basis for the morphologic sequence of extinct human types.

On my various travels to the sites of Early Man in Asia no problem seemed more urgent than this age question of Fossil Man. To solve this problem we need a great many data on the geologic formations which contain traces of early man. Such data have been collected from North China, Burma, India and Java, and all that is required now is to find a method which will enable us to correlate these data and integrate them into a coherent picture of the ancient world from which rose the dominance of Man over all other mammals. Indeed, if we could find a geologic way of dating the various finds, many hitherto unused and seemingly unrelated data would acquire new significance.

At present the chronology of Fossil Man in Asia is based chiefly on paleontology. In the case of *Sinanthropus* a great many fossils were unearthed with the human bones, and from them we receive a picture of the Pleistocene mammal fauna with which Peking Man appeared. Horse, straight-tusked elephant, buffalo, rhinoceros and deer, and a great many smaller mammals indicate a modern fauna, such as that which roamed over the temperate steppe and forest lands of Asia up to the close of the Ice Age. The majority of these animals were ruminants dependent on good grazing such as is not found any longer in the vicinity of Peking. The Peking Man fauna contrasts with two other fossil faunas, one of which is found in strata lying beneath the famous "yellow earth," or loess, of North China, while the other is intimately associated with the latter formation. The older fauna also is found in beds of loessic origin, as G. B. Barbour has shown. He called this older stage the "Sanmenian," and its fossil fauna is generally known as "Nihowan," from a locality in North China. There is in it a greater percentage of extinct genera, as compared to the Peking Man fauna, and there is a distinct correspondence with the "Villafranchian" fauna of Europe, which is generally considered to be of Upper Pliocene age. The loess fauna proper has mammoth and bison, and with it appears a type of fossil modern man who chose to settle right above the abodes of his progenitors, namely, one story higher up in the caves near Peking. If, as Teilhard de Chardin has lately suggested, the Nihowan fauna of North China is of Early Pleistocene age, then we have three distinct Pleistocene divisions as based on vertebrate fossils.

Such a threefold division of fauna we

might correlate with that found in lands south of the Himalayas. Following the late W. D. Mathews' suggestion, we would consider the Upper Siwalik fauna of India as marking a new wave of mammal migration from North America and Europe coincident with the Early Pleistocene. The second division would be represented by the combination of elephant, hippopotamus, horse, deer and buffalo, such as occur in the alluvial deposits of central India (Narbada- and Godavari rivers). As in China, this fauna is associated with early man of whom no other traces but well-made implements have so far been found in India. A third Pleistocene fauna would be represented by the cave fauna of Karnool in Southern India, where prehistoric bone industries abound.

Between India and China we would find a similar sequence of fossil faunas. In Burma, at least, are indications of a Lower, Middle and Upper Pleistocene mammal assemblage.

For Java, von Koenigswald has been able to differentiate between three Pleistocene faunas which he called Djetis-, Trinil-, and Ngandong. The second of these is characterized by *Pithecanthropus erectus* Dubois, while the latter is associated with neanderthaloid remains of Solo Man (*Homo soloensis neanderthalensis* Oppenoorth).

These areas embrace the region where to all appearance Man evolved into various races during the Pleistocene. It is an enormous terrain where fossil localities are scattered far and between. Moreover, the Pleistocene embraces a total time span down to the present of about 600,000 years, during which the fauna could adapt itself to environmental changes as it did in other parts of the world. Hence some of the paleontologic distinctions may be artificial. In fact, in Java there is a distinct transition between the Trinil- and Ngandong faunas, the latter differing from the *Pithecanthropus* fauna by very few types only. Also, there is no "cold" or "warm" type of fauna as there is in Ice-Age Europe. All this makes a formidable handicap for computing a reliable chronology of the Pleistocene, and the fact that fauna changed only twice during this period is sufficient reason for improving our stratigraphic methods in dating ancient man.

The type of stratigraphy that we need should fulfill three main expectations: (1) age determination of fossil human remains; (2) correlations of Pleistocene strata and their cultural records, and (3) reconstruction of environmental conditions.

A New Approach toward Pleistocene Stratigraphy

The Pleistocene is one of the few geologic periods known to have had a cyclic history which we find documented rather clearly by geological deposits over very wide areas. From the Pyrenees and Alps in Europe to the distant Himalayas, and from the Canadian plains to the Sierras of South America, reach our known records of what has so aptly been called the "glacial cycle." In many areas, such as the Alps, the Caucasus, the Himalayas and in North America, four glaciations and three interglacial periods are known. In other lands the records are less complete, but here also evidence is accumulating that the glacial cycle made itself felt in regions at, or south of, the equator. The theory of multiple glaciation has world-wide validity. This fact should be the cornerstone for any Pleistocene stratigraphy no matter whether we have to deal with glaciated or unglaciated terrain. For, if the climatic changes were world-wide, their effects upon sedimentation and relief-making processes must have been of world-wide extension.

As far as Asia is concerned, glacial cycles have been studied in some detail in the Pamir, Karakorum and Himalaya, which ranges constitute the backbone of

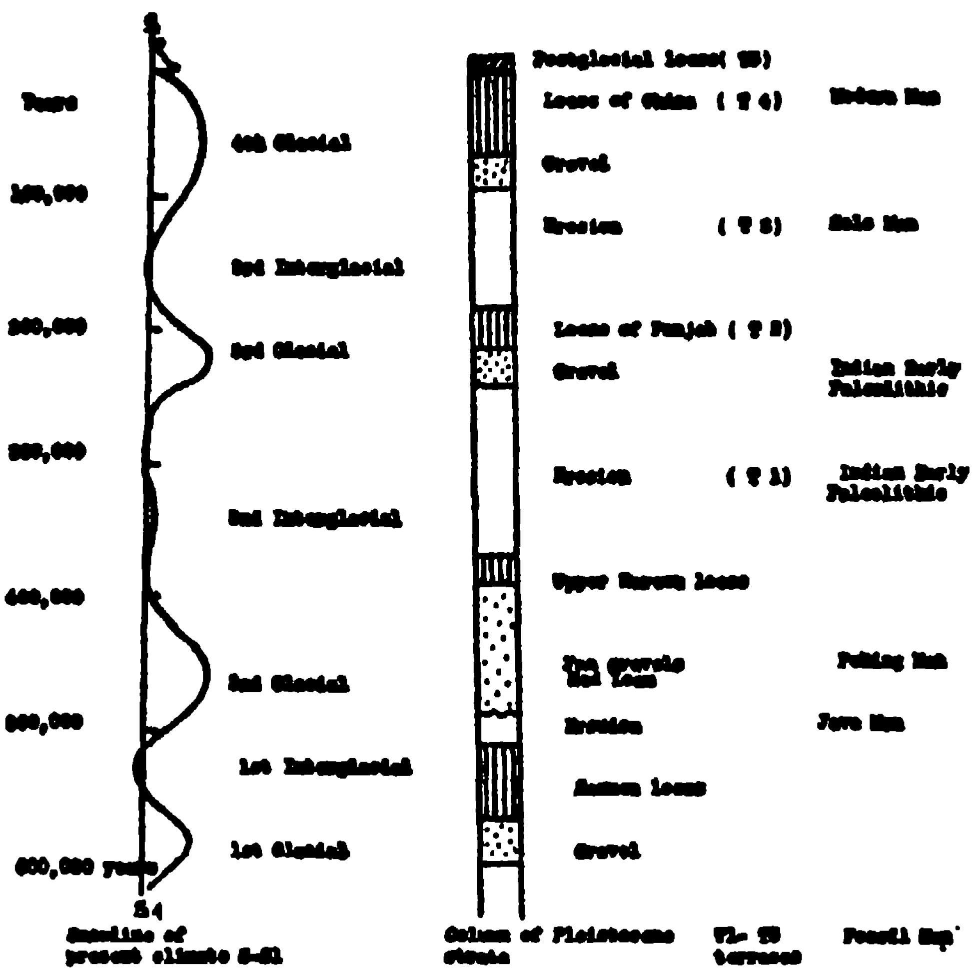


FIG. 1. SUGGESTED GLACIAL CHRONOLOGY IN ASIA

the high Asiatic massifs. Glacial phenomena have been reported from the Tienshan, Alai and Richthofen Mountains, and more recently they have been recorded in the Yangtze drainage. In none of these regions are the data as complete as in the western Himalaya, especially as here the glacial formations merge with the piedmont deposits containing mammal faunas. For this reason it seems justified to use this area as a reference region for the lands lying south and east of the Himalayas.

The stratigraphic approach described hereunder is based on field studies made on two journeys to India and Southeastern Asia. Chief assumptions made are: (1) that the climatic cycle of the Pleistocene was caused by world-wide changes of temperature causing pluvial and interpluvial phases in the non-glaciated regions; (2) that the approximate time span of the Ice Age embraces some 600,000 years, a figure based largely on the solar radiation theory of Milankovitch, and (3) that changes of climate are recorded in special soils and sediments which may under certain conditions serve as climatic indicators.

Obviously, an appreciation of the climatic cycle presupposes a conception of temperature fluctuations in the Himalayan region. These were computed as indicated in Fig. 1 on the basic assumption of F. Klute (1928) according to which the present position of the snowline[1] corresponds to present climatic conditions, as the last glacial snow-line corresponds to the last glacial climate. The temperature fluctuations in the western Himalayas were computed from the varying positions of snow-lines during the Ice Age, from the paleobotanical, paleontological and sedimentary nature of Pleistocene formations.

For the first Himalayan glaciation (600,000 years ago) we calculated a depression of snow-line by 1,600 meters, which corresponds roughly to a lowering of mean annual temperature of 8° C. (at 33° N. latitude). During the First Interglacial, climate was warmer in the Kashmir region than it is to-day and somewhat more moist, as indicated by the spread of the pine-oak forest toward the inner Himalaya (de Terra and Paterson, Carn. Inst. Publ. 493, 1939). At that time temperature rose to about 1.5° C. on the annual mean. For the second glaciation (450,000 years ago) a depression of snow-line by 1,500 meters was already calculated by Dainelli (1922), which corresponds to an approximate drop of temperature by 7.5° C. as compared with the recent period. During the long Second Interglacial (280,000–400,000 years ago), the climatic optimum may have been similar to the present, though there were minor fluctuations as recorded by varves in Upper Karowa clays. We know that the beginning of this Interglacial was relatively dry because dust storms carried great amounts of silt from the piedmont region into the valleys. The Third Himalayan Glacial (225,000 years ago) calls for a depression of snow-line by 1,400 to 1,500 meters, or a temperature drop of 7° C. At that time the advance of valley glaciers was

[1] The snow-line is the upper level at which the snow melts.

SEARCHING FOR STONE IMPLEMENTS ON A GRAVEL TERRACE IN INDIA

TWO STUDENTS OF EARLY MAN MEET AT THE MONUMENT OF JAVA MAN NEAR TRINIL, IN JAVA. PÈRE TEILHARD DE CHARDIN AND DR. VON KOENIGSWALD.

enhanced by a preceding steepening of valley gradients due to mountain uplift. No data are available for the last Interglacial, but we may safely assume that it was somewhat drier and warmer than the preceding Interglacial because of the relative paucity of grazing animals in the adjoining plains from which larger ruminants, such as the elephants and buffalos, had already retreated. In Europe, also, the last interglacial climate is considered warmer than the present, as inferred from the floras of Pont-à-Mousson (France), Cannstatt (Germany) and Pianico-Sellere (Lake Ivrea, Upper Italy). The last glaciation in the Himalayas was accompanied by a drop of snow-line of 900–1,000 meters, corresponding to a temperature drop of 4.5–5° C. There were three cold subphases as recorded by terminal moraines. From then on a gradual rise of temperature may be assumed, though it must have been interrupted by one or two brief reverses in postglacial time during which the snow-line dropped to as much as 600 and 400 meters, respectively, leading to one or two brief ice-advances.

Influence of Climate on Sedimentation

The first question that arises concerns the nature of the sedimentary composition in the plains region, because if there is correspondence between glacial and non-glacial deposits we may expect that such is the case practically everywhere in lands adjoining the Himalayan highlands. From Fig. 1 it would seem obvious that there is close correspondence between glaciation, gravel accumulation and pluvial conditions in the non-glaciated region.

As to the correspondence of glaciation and alluviation, T. T. Paterson and I (Carnegie Inst. Publ., No. 493) have shown that in the case of Kashmir the glacial gravels can be traced for long distances into the neighboring lowlands of India. Especially the fluvio-glacial gravels of the second glaciation make very conspicuous fans at the outlet of the Himalayan transverse valleys. These fans show themselves uniformly dissected and the valleys are filled with a younger gravel which is capped by loess. This deposit can be correlated with the third ice advance, and the terrace belonging to this phase was traced up to the terminal moraines in southern Kashmir. The Third Interglacial was a phase of erosion, as was the preceding Second Interglacial, so that when glaciers later advanced a fourth time the melt-waters carried their load into these younger valley cuts. There is, then, a clear rhythm of deposition to be noted in this area which is chiefly a function of climatic changes. Successive uplifts can not produce such close correspondence of gravel terraces in the glacial and non-glacial regions. There is, for instance, the same succession of gravels and terraces in Burma, over 1,500 miles distant from the Kashmir region. My most recent observations in the Irrawaddy Valley, in Burma, have shown that this correspondence exists in regions lying some 400 miles distant from the glaciated tract. In such cases it is necessary to ascribe greater power of transportation to the streams of the Pleistocene descending from the glaciated highlands, because not only are the gravels coarser than any laid down in post-glacial times, but they are much thicker and usually connected with soils suggestive of heavier rainfall.

Such a process of alluviation can not be explained solely by the melting of snow or glaciers in the highlands, because at that time water was actually still locked up in the form of ice, and rainfall may well have been less in the mountains. Also, the melting of glaciers is not a catastrophic process which enhances stream power, but a very gradual waning which may lead to local accumulation of débris (outwash fans) but never to formation of shingle sheets trailing for hundreds of miles away from the ice-

bound highlands. The formation of such enormous gravel sheets demands specific conditions of climate.

Such conditions evidently corresponded to glaciations and may well be pictured as pluvial periods. Increase of rainfall was a sequential effect of the lowering of temperature because of the refrigerated air masses resting over the snow-bound Himalayas and over other ranges to the east. These uplands comprise some two million square miles of which at least 60 per cent. were covered under ice and snow during periods of glaciation. Cold air rested over these highlands, and barometric "highs" must have been more common then. No doubt the monsoon wind blew against this cold land and created cyclonic conditions which caused condensation of moisture. At such times precipitation must have been greater than nowadays, and therefore we can speak of pluvial periods, as far as these piedmont and plains regions are concerned. Slope streams must have been choked with débris because of intensified nivation, frost-action and glacier outwash. Frequent and torrential rains carried this excessive load into the plains where it spread out in the form of fans which subsequently coalesced, forming wide marginal gravel belts. Such alluviation was increased by occasional subsidence of the plains country; at places these gravel sheets are several thousand feet thick. Another factor that aided in the formation of these gravels was the removal and redeposition of great masses of half-consolidated coarse sediments, such as abound in the Siwalik Hills, as well as in the piedmont regions of Central Asia.

Obviously, in these regions it should be possible to recognize three to four gravel zones and the three erosion periods which mark the interglacial or interpluvial stages. But these gravels might by chance appear in similar successions in areas lying thousands of miles distant from one another and still owe their ori-

ICE-AGE GRAVEL OVERLAIN BY LOESS CONTAINING PALEOLITHIC TOOLS
SOAN VALLEY, PUNJAB.

WHERE ELEVEN SKULLS OF NEANDERTHAL MAN WERE FOUND
NGANDONG TERRACE, NGANDONG, SOLO RIVER, JAVA.

gin to different climatic or mountain-making conditions. Such uncertainty, however, might be eliminated if we consider the soils that go with these gravels.

The Climatic Conditioning of Soils in the Pleistocene

Vast regions in China, central Asia and India are covered by Ice-Age soils such as loess, loessic siltstones and red earths, which in most cases are closely associated with gravels. In Kashmir and the Punjab and in certain regions of Sinkiang (Chinese Turkestan) there is close connection between the last glaciation and loess deposition. In India the Potwar loess is Third Glacial, and in Burma there is a loessic silt belonging to the fourth terrace, which corresponds probably to the last glaciation. G. B. Barbour has shown that in China loessic beds occur in the Sanmenian stage (Upper Pliocene or Early Pleistocene). This would clearly argue for an Early Pleistocene Age, a conclusion which is equally justified in the case of Burma and India. Here the Upper Siwalik and Upper Irrawaddy siltstones contain many glacial clays. These earlier loesses are compact and always in tilted position, while the younger loesses are loose and rarely disturbed by later mountain making.

In fact, taking into account all the evidence on loess and loessic deposits, it would seem as if there were four of these glacial eolian soils, for in the case of Kashmir the "Upper Karowa beds" mark a period of late Second Glacial and Second Interglacial dust storms, adding another loess to the three kinds already mentioned.

A second type of soil which we might use as climatic indicator is found in a group of tropical and subtropical soils, such as laterites and red loam. Very often, as in Upper Burma and in South China, these are found with pluvial gravels. They distribute themselves in such

a fashion as to suggest changing periods of greater and lesser rainfall. In some cases, as in the terraces of the Irrawaddy in Upper Burma, the ground-water laterites are invariably associated with stages of alluviation; and since these correspond in type and number to those found in the glaciated tracts of the Himalayan Highlands, I suggest that they represent the precipitates of a pluvial climate. It is to be noted that such fossil laterites occur down to 20° latitude in regions which are known as "dry belts," with precipitation less than thirty inches a year.

There are other soils in these piedmont lands which are called "kankar," planosol or concretionary hard pan soils. In Burma these soils are conspicuous on surfaces having undergone prolonged weathering under drier climatic conditions. Very often they are buried deeply under younger alluvial and eolian formations.

A special type of soil is found in the more humid highlands of the Shan States and Yunnan. These are lateritic fans and red loams that appear associated with karst relief. These soils, especially the boulder fans, are often connected with cave and fissure deposits containing a Middle Pleistocene type of fauna (*Stegodon orientalis, Elephas namadicus*, orang, porcupine, deer, etc.). The famous gem-bearing gravels and sands of the Ruby Mines District in Upper Burma belong to this category. Similar soils from Kwangsi and Szechwan provinces of China have been described by J. Thorpe. Quite possibly their extension is greater than we know now. In Malaya the tin-bearing alluvium is associated with such fossil soils, indicating heavy erosion under pluvial conditions.

The correlation of these fossil soils with glacial deposits makes an interesting and important problem for Pleistocene

SITE OF MODJOKERTO WHERE MOST ANCIENT HUMAN FOSSIL WAS FOUND
EAST JAVA.

PITHECANTHROPUS SITE, SANGIRAN, JAVA, WHERE SKULLS WERE FOUND
ONE SKULL WAS DERIVED FROM THE UPPER LEFT SCAR ON THIS SLOPE.

geology. At the moment we can not say more than that the glacial gravels merge into pluvial (or fluvial) formations in the piedmont and plains regions, and that the glacial cycle is thus clearly documented over areas lying beyond the glaciated tracts. This correlation becomes more significant still if we view the terraces of Central and southern Asia as a whole.

Influence of Climate on Terrace Formation

Previously I have shown that the river terraces of southern and Central Asia show a surprisingly uniform pattern.

As for Central Asia, E. Huntington had ascribed the gravel formations to the erosive effects of dry periods during which soil wash proceeded rapidly because of prevailing aridity. The studies of Dainelli, however, on the glacial terraces of the inner Himalaya, and those made recently by Paterson and me give proof of the synchronous formation of glacial débris with Pleistocene gravels. This holds especially for the aggradational terraces II and IV of our system, while terraces I and III are of interglacial origin.

Under the conception of pluvial stages being concomitant with glacial stages (at

least, as far as the areas under discussion are concerned), it is not surprising that the same terraces should be found over regions covering thousands of miles in a west-easterly direction. In fact, between the Indus and the Yangtze Rivers this relation seems to prevail throughout, though much work remains to be done in intervening areas. The terrace sequence here found is characterized by five terraces, of which four are Pleistocene and one of post-glacial age, the oldest and highest being superimposed on gravel fans which are younger than the tilted beds containing Villafranchian fauna. In the glaciated regions, TI is of Second Interglacial Age; terraces two and four mark stages of heavy alluviation corresponding to the third and fourth glacial (or pluvial) stages.

It is possible that a similar system of ancient stream levels exists on the middle Yangtze, as G. B. Barbour's studies suggest. Huntington has described five terraces from the piedmont regions and basins of Eastern Persia which may well correspond to our sequence. Confirmation of this would enhance our chances greatly of viewing the Pleistocene in these areas under the conception heretofore presented.

But the Pleistocene column has other characteristics which are almost equally common to all the regions mentioned: the erosional and structural breaks of the sequences. The largest of these is found between the beds with Villafranchian fauna and the Later Pleistocene. This angular unconformity is almost universally found from the Caucasus to Central and eastern Asia. Other breaks are found between the gravel fans and the loess, and in northwestern India even the loess was slightly effected by subrecent mountain making. Uplift during the Pleistocene amounted to 6,000 feet and more, and the total amplitude of crustal deformation in the sub-Himalayan ranges exceeded 12,000 feet. It is this factor which may account for the local thickness of the Pleistocene in the piedmont region.

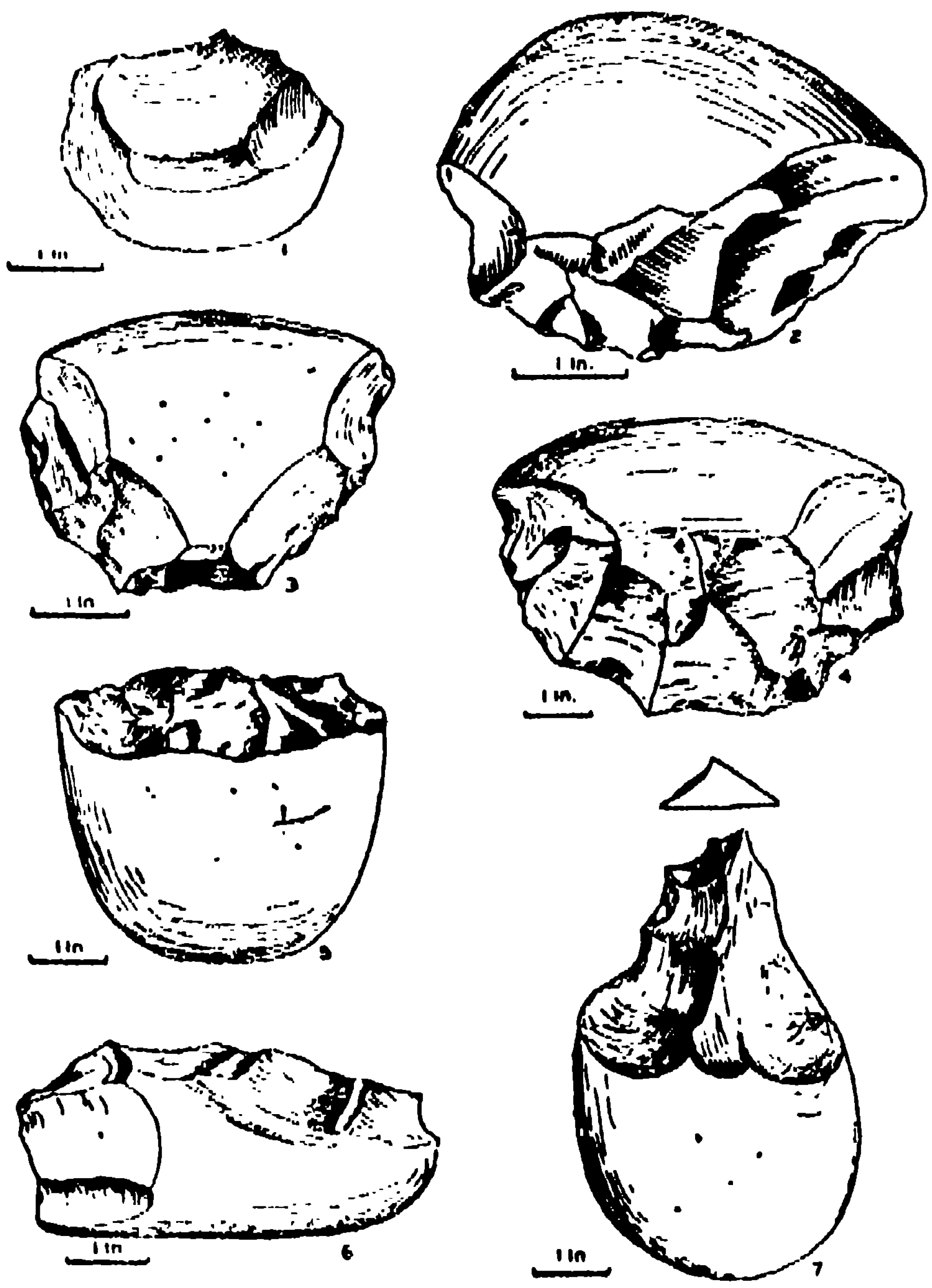
It is evident that the terrace sequence and the gravel zones enable us to divide the Pleistocene into more subdivisions than the paleontologic method can provide. Generally we can distinguish between four gravel zones and three major structural breaks in the sequence and, in addition, we have the five terraces and the soils which help to distinguish the pluvial from the interpluvial phases. It is interesting to see how this new stratigraphic scheme helps to clarify certain data on human origins in Asia.

Fossil Man and the Pleistocene Cycle

Under the conception of climatic changes, the phenomena of cave and fissure formations bearing human relics become more understandable. It explains the association of limestone caves, middle Pleistocene fauna and fossil man. Apparently the impact of the second

PEKING MAN, CHINA
AFTER RECONSTRUCTION BY F. WEIDENREICH AND SCULPTURE BY MRS. L. SWAN.

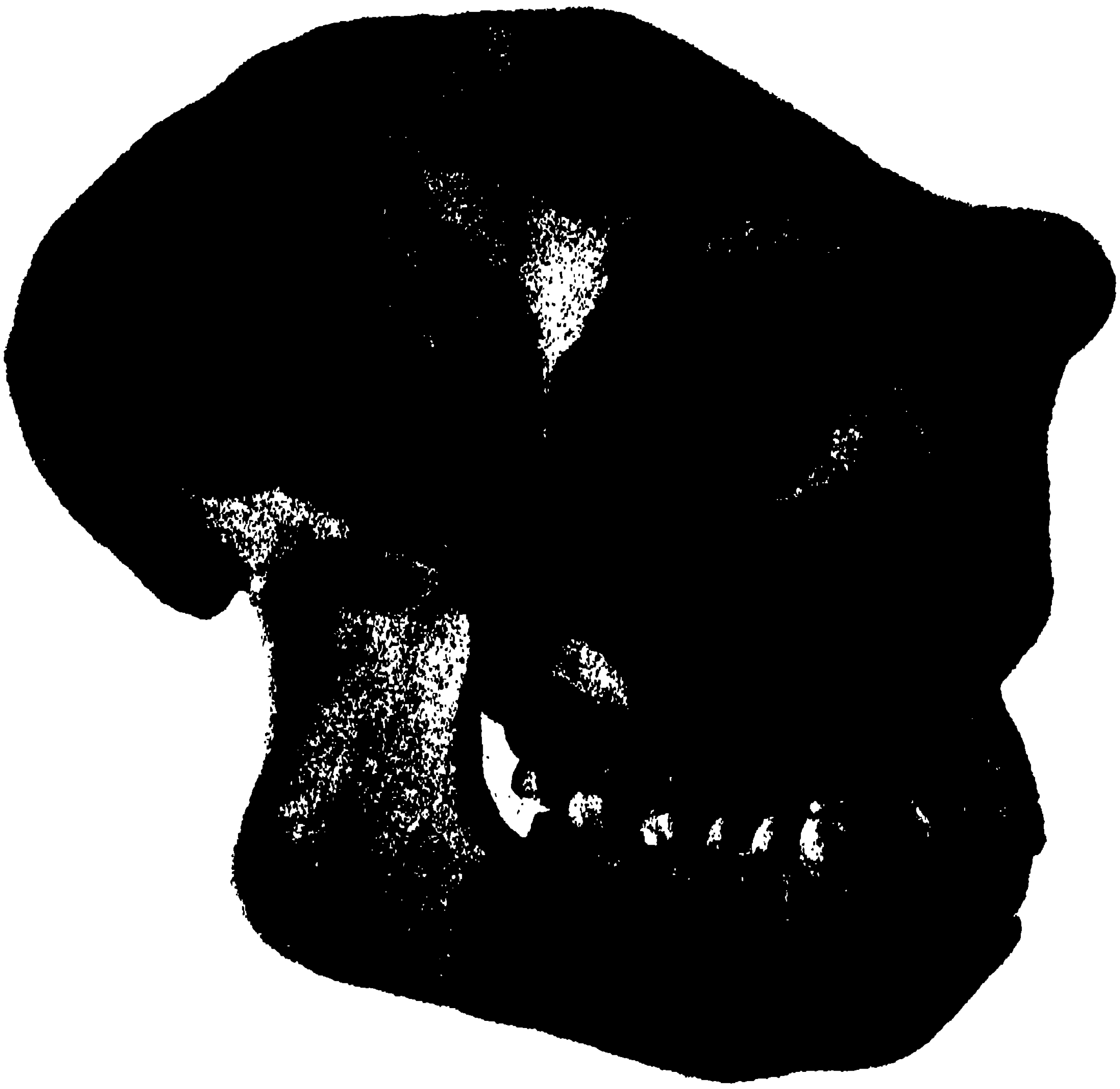
major Pluvial on the subtropic and tropic regions fostered existing karst formation in the limestone areas of China, Indo-China and Burma. In all of these areas a post-Villafranchian fauna appears intimately associated with fissure and cave deposits, such as at Choukoutien, the famous *Sinanthropus* site. Evidently ruminants were frequently trapped in sinkholes; in other cases, beasts of prey or even primitive man carried their victims to underground places or rock-shelters where they were subsequently buried under weathering products. Climate then was generally more moist in the peripheral regions, for in the plains of North China roamed buffalo, deer, antelope and elephant, a fauna which is quite unthinkable under present-day semi-arid conditions. We know that Peking Man himself hunted deer, for almost 70 per cent. of all fossils uncovered at Choukoutien belong to that family. Greater intensity of erosion due



OLDEST STONE-AGE TOOLS
FROM PLEISTOCENE GRAVELS OF NORTHWEST INDIA (SOAN CULTURE).

to pluvial conditions are indicated also by the thick piles of sediment which accompanied the karst formations. Under its impact land was wearing away rapidly and karstification took place on an unprecedented scale. Even outside of continental Asia similar conditions must have prevailed. In Java, along the Solo River, we find the remains of *Pithecanthropus* in alluvial sands that indicate intensive erosion and deposition. The fossil plants collected from these beds by the Selenka Expedition in 1907 were interpreted as indicating a slightly cooler and more moist climate than the present. In the neighboring karst of the Zuider Mountains are found the red loam formations with "Sino-Malayan" fauna (von Koenigswald, 1939), which also is of Middle Pleistocene Age. To me it seems most probable that Java Man lived at the time of the Second Pluvial, just as Peking Man existed during the early Middle Pleistocene, which corresponds to the second glaciation (perhaps 400,000–500,000 years ago).

Another interesting aspect concerns the distribution of Stone-Age tools. No paleoliths of good workmanship have been found in deposits antedating the second glaciation, or Second Pluvial. In the Siwalik Hills of the Punjab, as well as in Upper Burma, in North China and in Central Java the first real tools of man appear associated with a post-Villafranchian fauna in strata resulting from pluvial or greatly accelerated conditions of erosion. This was the fan-building stage. Extensive gravel fans spread throughout the piedmont lands and provided Early Man with the incentive to experiment with stone. The industry of Choukoutien and the coarse, quartzite flakes of the Boulder Conglomerate in northern India, as well as the crudely worked pebbles and flakes of the highest terrace gravels in Burma, all bear the stamp of experimentation rather than of established flaking tradition. Because of their close association with Peking Man



JAVA MAN
(PITHECANTHROPUS SKULL IV FOUND BY VON KOENIGSWALD, 1939.) RECONSTRUCTED BY PROFESSOR F. WEIDENREICH.

in north China, I am inclined to regard these early pebble and flake industries as manifestations of a primitive intelligence decidedly less developed than that recorded by the Abbevillian and Acheulian tradition, in Europe and East Africa.

Already during the Second Interpluvial, or Interglacial, these early paleolithic cultures differentiated into an eastern and a western group. The latter was the hand-axe tradition which may not have necessarily been carried to India from East Africa or Europe, but quite possibly it developed in India independently from Africa. The hand-axes from Madras, for instance, have little in common with either the Abbevillian of France or the hand-axes found in Java. Though equally old, they may well have been made by people who had developed their own technique. We need not assume big migrations whenever we notice similarities of techniques for, after all, Early Man had only a very limited choice of stone flaking at his disposal. The fact that this western-tool complex in India was mixed with the eastern pebble-chopper culture is indicative of early differentiations, probably of a racial type. In this eastern realm crude pebble choppers take the place of the "bi-face" and dominate (with the flake-chopper and cleaver) the eastern technique. East of the Brahmaputra no real hand-axes or Acheulian traditions have been found. In Java also (though hand-axes are numerous) none of the typical bi-faces, or cleavers, occurs which characterizes Central and northwestern India. Between these regions there are funda-

mental differences in tool technique as far as the Paleolithic is concerned. We suggest that these variations are rooted in racial or phylogenetic differences. When it comes to detecting Mousterian or even later Paleolithic cultures, such as abound in the Upper Pleistocene formations of Asia Minor, East Africa and Europe, we see no equivalents in southern or Far Eastern Asia. The "loess cultures" of north China are typologically different from those found under the Würmian loess of central Europe. They belong in a class by themselves and seem to be rooted in the eastern pebble- and flake-tradition rather than in any Western culture.

Little understood as such typologic differences are, yet they become significant in the light of our stratigraphic scheme. For the first time their contemporaneous appearance is revealed, and with it the outlines of cultural and racial boundaries begin to emerge, even though faintly, from the dimness of those very remote ages. With this knowledge comes the demand for a new classification of the Asiatic Stone-Age tools. Heretofore they have been labelled with European terms, a procedure which needs to be changed in the light of this discussion.

The stratigraphic range of the human fossils found so far in Asia has been indicated in the figure. From it may be seen that the *Pithecanthropus* race was the earliest, having had a range from very early Pleistocene times (600,000 years ago) to the Second Pluvial and possibly Second Interpluvial. I may add that the great antiquity of this type is not inferred solely from the more primitive anatomy of the skull as compared to that of *Sinanthropus*, but also from the Early Pleistocene Age of the fossil infant from Modjokerto in eastern Java which F. Weidenreich considers to have belonged to an immature *Pithecanthropus*. The Peking Man race in North China appeared in the Second Pluvial and may have lasted into the long Second Interpluvial. Neanderthal Man of Java (Solo Man) is Upper Pleistocene, but judging from the stratigraphic range of worked flints, he may well have dated back to the close of the Second Interpluvial, as he actually did in central Europe (*Homo steinheimensis*). The fossil *Homo sapiens* is represented by Wadjak Man in Java and by the Upper Choukoutien cave types in China, as described by F. Weidenreich.

Such a chronologic sequence indicates that human evolution proceeded in Asia rather independently of climate, though future studies may prove that the major climatic changes brought about certain optima of life conditions. Such a period may have been the Second Pluvial (450,000 years ago). At that time the wide steppes of eastern and southeastern Asia must have changed to forests and the ocean level must have dropped due to wide-spread locking up of water through glaciation. This lowering must have formed a landbridge between Java and the mainland which permitted mammals to migrate freely from China into the Sunda region. This theory explains the appearance of a Middle Pleistocene "Sino-Malayan" fauna in Java at the time when *Pithecanthropus* lived on the banks of the Solo River. The shifting of vegetation belts and of coastal lands in southeastern Asia may have guided the early migrations of Man, and for this reason it would seem worth while to consider the soil-geological and paleobotanical approach in any future studies on human origins in Asia.

A PROPOSED GREAT PLAINS NATIONAL MONUMENT

By VICTOR H. CAHALANE[1]

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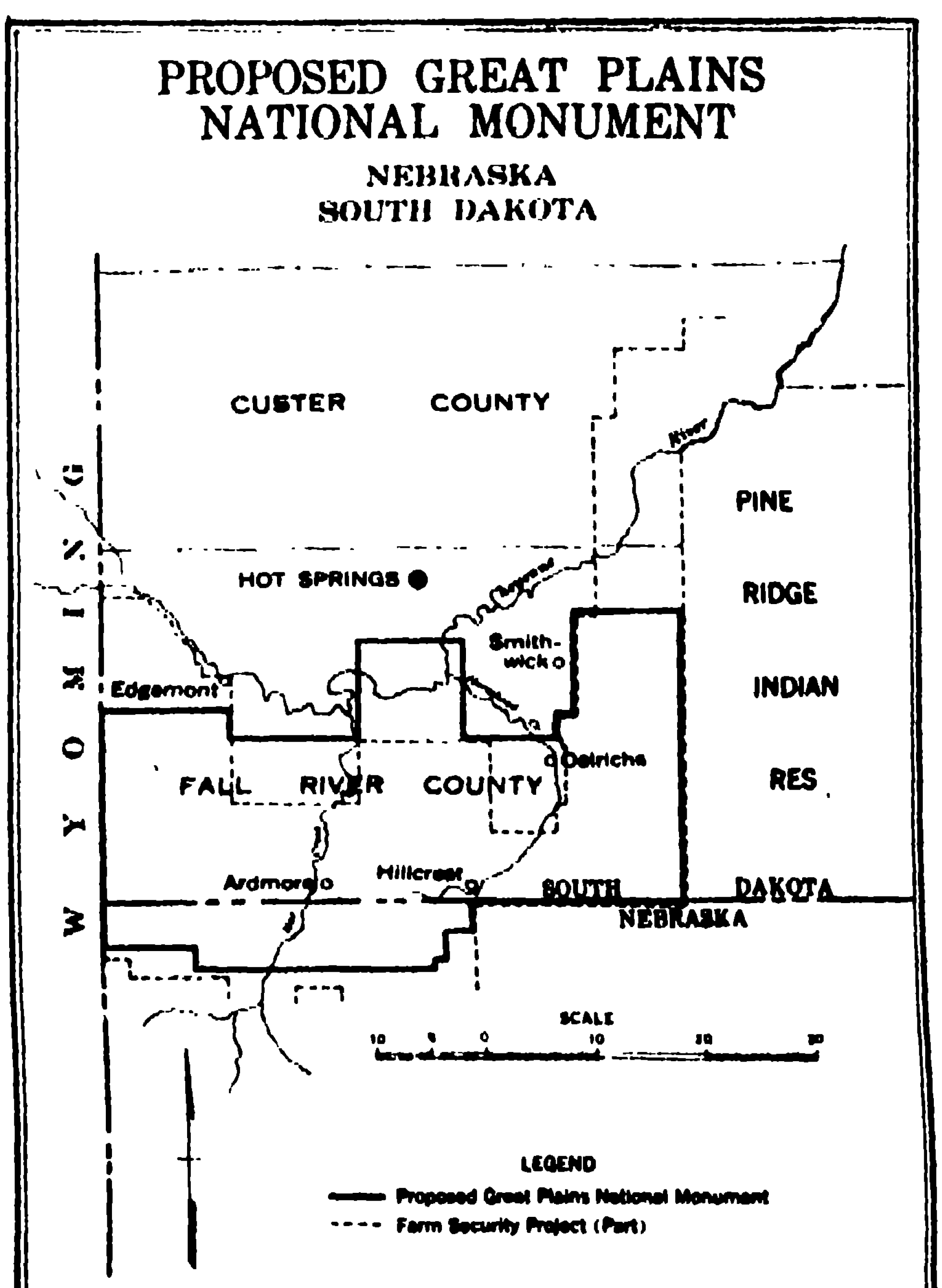
PROGRESS of civilization with accompanying development is changing the face of nature. In the eastern United States there remains hardly a square mile of unmodified vegetation. Even the surface of the earth itself—the hills and valleys, the course of streams—in places has been changed, either directly by engineering or indirectly by erosion. Life dependent upon these habitats must change with them or become extinct. Except through written descriptions, man loses contact with historical phases of his environment and opportunities for scientific work on it.

In the following paper, I have drawn freely from writings and unpublished reports of Dr. V. E. Shelford and other members of the Ecological Society's Committee on Preservation of Natural Conditions. Certain information on the animal and plant life of the area has been taken from Petry and Visher's account in the "Naturalist's Guide to the Americas" (1926). The forecast of probable vegetative cycles under protection, described on pages 132 and 133, is adapted from an unpublished report by Dr. W. B. McDougall.

A system of national reservations has therefore been devised within which samples of original America, with their plants and animals, may be perpetuated. National parks preserve outstanding scenery; national monuments protect natural phenomena and historic sites and structures. A comprehensive system of national monuments should include samples of ecological plant associations and, with them, their characteristic animals. Surely the prairie is a highly important kind of environment, and a small portion is worthy of preservation. The National Park Service, therefore, aided by the National Research Council and by the Ecological Society of America, has been for a number of years considering possible areas in the short-grass prairie region. Recent field inspections have indicated that a typical one has been found.

An area suitable for designation as a Great Plains National Monument must meet a number of important specifications if it is to serve its purpose. It must for several reasons be of large size. From



OUTLINE MAP OF PROPOSED MONUMENT

[1] Formerly chief, Wildlife Division, National Park Service.

Photo, 1938, by C. H. Wegemann, National Park Service

VALLEY OF A TRIBUTARY OF THE HAT CREEK DRAINAGE

EAST OF PROVO, SOUTH DAKOTA. THE YELLOW PINES IN THE MIDDLE DISTANCE ARE ON THE DAKOTA FORMATION WHERE IT COMES TO THE SURFACE. SOME DIVERSITY OF COVER AND SURFACE IS ESSENTIAL FOR THE LARGER MAMMALS OF THE GREAT PLAINS, AND THIS EXISTS IN THE NORTHERN PORTION OF THE PROPOSED GREAT PLAINS NATIONAL MONUMENT ALONG THE CHEYENNE RIVER.

the recreational point of view size is important, for the greatest inspirational value of the plains is to be gained from large areas free from traces of human developments. The scientist also demands large natural areas for some types of research. The preservation of truly natural conditions of vegetation requires that outside, man-caused factors be excluded. To prevent pollution of even a comparatively small central area by exotic plants that may spread and travel as seeds on the wind, a wide surrounding buffer zone under rigid control is a requirement. A long step toward permanent protection of numerous bird species consists in preservation of their normal habitat in some expansiveness. Also, if the larger members of the fauna of the Great Plains are to be restored under natural conditions a great acreage is necessary. Bison, antelope and elk need large amounts of forage, which in the short-grass type is not truly abundant. If the bison, particularly, is to be preserved as a wild species in the United States, it must be granted a large natural range free from the domesticating confinement of small fenced parks. From a consideration of all these points, it seems that a million-acre tract would be needed.

Size being a necessity, it is also evident that the shape of the area selected would be important. The most ideal one would be essentially isodiametric, for an elongated section of land would be more and more exposed to outside influences with any increase in the ratio between length of boundary and acreage.

Although not ideal in all respects, most practical requirements are fulfilled by an area of about three quarters of a million acres occupying southern Fall River County, extreme southwestern South Dakota, with a relatively small extension into adjacent Sioux County, Nebraska. Approximately 50 per cent. of the desirable lands are in federal or state ownership (notably land retirement

Photo, 1938, by C. H. Wegemann, National Park Service

LOOKING EAST FROM A POINT JUST NORTH OF ARDMORE, SOUTH DAKOTA

THE LOW HILLS OF THE PIERRE FORMATION, BY SPARSE COVER AND PRESENCE OF WEEDS, SHOW DISTINCT SIGNS OF DROUGHT AND ABUSE THROUGH OVER-GRAZING. THE LINE OF TREETOPS ACROSS THE MIDDLE DISTANCE IS ALONG A (DRY) WATERCOURSE OF THE HAT CREEK DRAINAGE.

purchases of the Farm Security Administration now under the control of the Soil Conservation Service), while over 8 per cent. more are county property.

The area selected for a Great Plains National Monument project is mostly of Cretaceous (Pierre shale) origin of a type uniform with the plain west of the Missouri River and exclusive of the Black Hills area. The tough gumbo soils of this semi-arid region are much eroded in some places, but the project has escaped severe cutting. The rounded hilltops vary in elevation from 100 to 300 feet above the valley bottoms, or coulees. Most of the streams are temporary in character, often going dry except in periods of frequent rain.

The climate of southwestern South Dakota is relatively arid, as the average yearly precipitation varies from 16 to 20 inches. A distinct rainy season starts about April 1 and ends early in October. During that time approximately 75 per cent. of the yearly precipitation occurs. Summer rains are more local in character than those in the spring and fall, and the rainy period coincides with the growing season. November, December, January and February are the driest months of the year. Winter temperatures average about 26° F. January is the coldest month of the year. Snowfall is usually light, except in March. The lowest temperature ever recorded in Fall River County is −42° F. at Oelrichs. Summer temperatures generally average around 65 degrees but exceed one hundred usually more than once a year. July and August are the hottest months. During periods of coldest weather, there is not much wind and the severity of the cold is somewhat mitigated by low humidity at the time.

The dry plains of the western part of the State of South Dakota, including the area under consideration, are covered by a short grass sod in which grama grass (*Boutelous gracilis*) and buffalo grass (*Buchloe dactyloides*) were originally dominant. Many xerophytic herbaceous plants as loco (*Oxytropis lambertii*),

Photo, 1938, by C. H. Wegemann, National Park Service

SOUTHEAST FROM ABOUT 6 MILES EAST OF ARDMORE, SOUTH DAKOTA

THE VEGETATION HAS BEEN NOTICEABLY THINNED BY OVER-GRAZING, DROUGHT AND ACCOMPANYING FACTORS, ALTHOUGH THE SOD HAS NOT BEEN DISTURBED. THIS SCENE IS NEAR THE CENTER OF THE GREAT PLAINS NATIONAL MONUMENT PROJECT.

Photo, 1938, by C. H. Wegemann, National Park Service

SOUTH FROM ABOUT 12 MILES EAST OF ARDMORE, SOUTH DAKOTA

THE MORE DROUGHT-RESISTANT AND UNPALATABLE PLANTS HAVE RESISTED STRESS AND HERE FORM ONE OF THE HEAVIEST COVERS IN THE AREA. THE MOST DISTANT RIDGE IS IN NEBRASKA.

Artemisia frigida and *Chrysopsis villosa* are mingled with the short grass sod and have become more important elements as range deterioration progressed. Small remnants of the short grass vegetation persist in the badlands.

Along the few stream courses, most of which cease to flow at least during the long hot summer, cottonwoods and willows are the most prominent floral elements. Elm and box elder, however, are not uncommon. Scattered red cedars are found on the upper reaches of the tributaries and in most situations a buffalo berry (*Lepargyrea argentea*) occurs.

The grassland is the home of the northern skunk and spotted skunk (*Spilogale*), the badger, prairie coyote, black-footed ferret, swift fox, black-tailed prairie dog, the pallid striped ground squirrel (*Citellus tridecem lineatus pallidus*), sage pocket gopher, pocket mice (*Perognathus* ssp.), kangaroo rat, white-tailed jack rabbit, Wyoming cottontail and the Osgood deer mouse. The gray wolf, bison and mule and probably white-tail deer formerly occurred there but are now extinct in the region. The Audubon bighorn, which once lived along the rivers and in "badlands" of any size, is now completely extinct. Pronghorn antelope were numerous in early times and may occur accidently as they are present west of the project in Wyoming and some distance to the south around Agate, Nebraska.

U. S. Department of Interior

SITE OF CAMP NEAR CHURCH BUTTES, WYOMING, IN 1870

NOTE CLEAR STREAM WITHIN ITS BANKS AND VALLEY BOTTOM COVERED WITH TALL GRASS, UNLIKE CONDITIONS TO-DAY. THE RANK GROWTH OF GRASSES SHOWN WAS PROBABLY WESTERN WHEAT-GRASS, PRAIRIE CORD GRASS AND SOME JUNCUS SPECIES.

Along the larger stream courses the list of mammals may be somewhat larger. Bats come to drink here and raccoons to catch crawfish. An occasional western fox squirrel is found in the groups of large cottonwoods and willows. The Cheyenne and White Rivers and many of their larger tributaries are known to contain Missouri River beaver (*Castor canadensis missouriensis*). Under present

Soil Conservation Service

SAME SITE AT CHURCH BUTTES, WYOMING, AT PRESENT TIME

THE VEGETATION IN THIS PHOTOGRAPH, 67 YEARS LATER THAN PRECEDING PICTURE, IS PREDOMINANTLY A SAGEBRUSH TYPE. THE MAIN SPECIES ARE BIG SAGE AND RABBIT BRUSH, WITH TRACES OF WESTERN WHEAT, PRAIRIE CORD, JUNCUS AND DROPSEED SCATTERED THROUGHOUT THE AREA.

conditions, it is fairly certain that no beaver occur within the boundaries of the proposed grasslands area.

Although this section of the plains is not a vitally important habitat for vanishing bird species, several rare or uncommon kinds use it during at least a portion of the year. The long-billed curlew, once common, is still found nesting there. Four were seen at Hillcrest on June 14, 1938, and several others the following day near Folsom, about 20 miles north of the northeastern corner of the proposed monument. The whooping crane was recorded by H. H. Sheldon on October 4, 10 and 16, 1915, on the Pine Ridge Indian Reservation. The writer also saw a flock passing very high over Sheep Mountain, at the western end of the Badlands, on October 13, 1935. Prairie sharptailed grouse were once common and would regain their former numbers with adequate protection and the return of normal vegetation. There are records of the greater prairie chicken from nearby areas (Badlands, Pine Ridge Indian Reservation). Water-loving birds are comparatively scarce, for their special environment is of course very limited, but four herons, five sandpipers, two geese and seven species of ducks have been noted in the project or within 25 miles of the boundaries. A few mallards and pintails are found on every permanent stream, even though small in size. Surface water is at a premium on the plains, especially in the southward migration, and ducks are surprisingly abundant in fall. Birds of prey are numerous in species and individuals. Eight kinds of hawks have been recorded in addition to the golden and bald eagles and the osprey.

The only permanent avian resident represented by many individuals is the desert horned lark, which in late summer and fall is very abundant. Great numbers are killed at this time by speeding automobiles. Probably these are almost entirely young of the year, for no dead

larks are to be found after the end of December, although survivors are still abundant on the roadsides. Longspurs of some species are found in all seasons, the chestnut-collared and McCown's longspurs nesting here abundantly and the Lapland longspur wintering. Two other members of the sparrow family, the lark bunting and the western vesper sparrow, are very numerous; the former is quite characteristic. Other prominent nesting birds are the Brewer blackbird, Sennett's nighthawk, upland plover and burrowing owl. The latter, unfortunately, is comparatively scarce, for extermination campaigns aimed against prairie dogs have indirectly affected the birds dependent on the burrows for dwelling and nesting places. Several kinds of birds nest in the groves of scattered trees along the streams, but often feed on the steppe far from their nests. Examples are: the ferruginous rough-legged, Swainson's and sparrow hawks. Cliff and barn swallows, nesting on cliffs or about buildings, are also seen often, as well as the bank and violet-green swallows. The total number of bird species is especially large, because the western Dakotas lie on the meeting-line of eastern and western avian faunas, where forms common to both mingle. A great increase in the number of individuals would almost certainly follow restoration of normal ground cover and the re-elevation of the water table to its natural level.

The most common snake is the plains bull-snake (*Pituophis sayi*), with the plains blue racer (*Coluber constrictor flaviventris*) next and the prairie rattlesnake (*Crotalus confluentus*) third in most places and seasons. The horned-lizard (*Phrynosoma*) is numerous in many localities. The common toad (*Bufo woodhousii*) is seen frequently. The Great Plains toad (*Bufo cognatus*) is characteristic but not abundant.

The area proposed for establishment

U. S. Bureau of Biological Survey

AUDUBON BIGHORNS ONCE LIVED IN THE BREAKS

THE LAST AUDUBON BIGHORNS OR BADLANDS MOUNTAIN SHEEP WERE EXTERMINATED FROM THEIR GREAT PLAINS HABITAT ABOUT 1918; CONSERVATION POLICIES ARRIVED TOO LATE TO SAVE THEM. THEIR SURVIVING RELATIVES OF THE ROCKY MOUNTAIN VARIETY WERE PHOTOGRAPHED ON THE NATIONAL BISON RANGE, MONTANA.

as a Great Plains National Monument has been much abused by overgrazing and to a small extent by plowing. Any plans for restoration to a normal condition must take this into account. While some erosion control work can probably be carried on in order to hasten rehabilitation of the land, time is the agent that will heal the scars most effectively.

The short grasses of the plains region may be considered as representing the climax type of vegetation for the region—in other words, the most mesic vegetation that the climate, especially the water supply factor, will support. The hillocks will probably be too dry for the climax vegetation, but these will be worn down until conditions suitable for the climax are attained. On the other hand, if there are shallow depressions too wet for the climax, they will gradually fill up until the same medium conditions are reached. When the climax vegetation has been established, it will persist indefinitely unless destroyed by one means or another, or a change occurs in the climate. When the climax vegetation is destroyed by any means, the resulting bare area will always be drier or wetter than it was when occupied by the climax vegetation. As a result there will be a natural succession of plant forms on the area until the medium conditions that will support the climax vegetation have returned.

When the short-grass plains climax vegetation is destroyed, the resulting bare area is moister than the areas occupied by the vegetation because an immense amount of water is lost through the plants. The first stage in the succession on such an area is an early weed stage, which occurs from one to three years after the area has been abandoned. The plants are principally smartweed (*Polygonum aviculare*), Russian thistle (*Salsola pestifer*), verbena (*Verbena bracteosa*), gum weed (*Grindelia squarrosa*), plaintain (*Plantago purshii*) and six-weeks fescue (*Festuca octoflora*).

National Park Service, by Frank Oberhansley

BISON AND ELK WERE ONCE PLAINS DWELLERS

BUT ECONOMIC DEMANDS EXTIRPATED THEM FROM AGRICULTURAL AND GRAZING LANDS ON THE AMERICAN PLAINS. EXCEPT FOR A HERD IN CANADA, BISON NOW PERSIST IN A TRULY WILD STATE ONLY IN THE WOODED MOUNTAINS OF THE YELLOWSTONE NATIONAL PARK.

U. S. Bureau of Biological Survey

BULL ELK IN VELVET

ELK OR WAPITI WERE ONCE RESIDENT IN BRUSHY CREEK-BOTTOMS THAT FURROW THE GREAT PLAINS.

During the second stage these weeds increase until they use all of the available surface water during the season. This stage lasts for two to five years and, before it ends, young plants of tumblegrass (*Schedonardus paniculatus*), *Gutierrezia sorothrae* and false mallow (*Malvastrum coccineum*) will be found.

In the third stage, lasting four to eight years, tumblegrass is dominant. This is a short-lived perennial grass and a surface feeder. It crowds out the annual weeds. Along with it will be found many plants of *Gutierrezia,* which is a deep-feeding perennial.

The fourth stage, lasting seven to fourteen years, consists largely of the deep-feeding *Gutierrezia,* together with some tumblegrass and occasional plants of buffalo grass (*Buchloe dactyloides*).

The fifth stage, 12 to 25 years, is dominated by buffalo grass, together with some plants of the earlier stages.

Finally, in the sixth stage, 25 to 50 years, buffalo grass and grama grasses (*Bouteloua*), long-lived, surface-feeding, short grasses, kill out the deep feeders by utilizing all available water before it penetrates to the deeper layers. Thus the typical short-grass vegetation is reestablished.

This succession may be modified by any number of local factors or by such climatic factors as wet and dry cycles. In general, however, it may be expected that it would take from 25 to 50 years to reestablish the typical short-grass vegetation in places where it has been destroyed.

This great area, if set aside for national monument purposes, would present peculiar problems in restoration, administration and protection. Keeping in mind the primary need for recuperation of the vegetation, provision must necessarily be made for the reintroduction of small numbers of the more conspicuous mammals now exterminated. Restoration of bison, elk and antelope presuppose the construction of a fence sufficient to prevent the animals from wandering to agricultural areas and such a project,

U. S. Bureau of Biological Survey

WATERFOWL FIND WATER SCARCE FOR NESTING.

BUT PARENTS, LIKE THESE CANADA GEESE, REARED BROODS WHEREVER WATER WAS AVAILABLE.

involving approximately 200 miles of boundary, would be a large task. Fence construction on such a scale would be by no means out of reason, as barriers of much greater length have been completed in Australia as public or state projects. In a large area, however, it is probable that fencing would not be needed for some time if watch were maintained over the animals' movements. Periodical herding of a comparatively small number of bison or other grazing mammals should suffice to prevent straying beyond the exterior boundaries.

Restoration of that large carnivore, the wolf, would, however, be attended with more serious difficulties. Nothing of this nature could be attempted until a tight fence could be constructed around the project in order to prevent natural gravitation of wolves to regions where their presence would interfere with economic interests.

It is probable that in time an entirely new road system could be laid out to suit the distinctly different uses of the land. The type of construction would be simple, for only low-speed traffic, principally seeking views instead of mileage records, would need accommodation. The traditional type of road for the Great Plains is the rudimentary one or two wheel tracks. It is believed that this, probably oiled to allay dust, would be sufficient for most of the monument and quite in keeping with its purposes.

A large staff, at least for administrative and protection purposes, would never be needed. Protection of the "game" mammals and other wildlife would also be less troublesome than in forested country and poaching much more easily detected.

Because of the nature of the experiment there should be no development in the popular sense of the term. The only

Haynes, Inc., Yellowstone Park

THE ANTELOPE ONCE WERE PLENTIFUL

IN THE PLAINS REGION WHERE THEY FORMED AN INTEGRAL PART OF THE BIOLOGICAL COMMUNITY. A BUCK PHOTOGRAPHED IN YELLOWSTONE NATIONAL PARK WHERE A HERD OF 800 IS FLOURISHING.

U. S. Bureau of Biological Survey

THE PLAINS WHITE-TAIL DEER NEEDS BRUSHY VALLEYS

AND DISAPPEARED FROM THE PLAINS WHEREVER THESE WERE "CLEANED UP" OR SETTLED.

development permitted would be that necessary for the protection of the area and to accomplish the purposes for which it would be set aside.

It is believed that the reservation of an adequate sample of the Great Plains, under administration that would preserve *all* factors of the environment, can be justified on scientific, economic and recreational grounds. Grassland is one of the most important of all vegetational features. Shantz's "Plant Resources" in Encyclopedia Britannica, 1930, pages 858--860, estimates the division of the 52 million square miles of the earth's land area as follows: desert, 13 million square miles; forest, 17 million square miles; grassland, 22 million square miles.

Furthermore, Shantz and Zon (Atlas of American Agriculture, Natural Vegetation, 1924, page 3) have estimated that 38 per cent. of the original total area of the United States was grassland. Agricultural use has converted some of this to tillage, and misuse has further reduced the arable area. From the economic and scientific point of view, therefore, it is of enormous importance that the remaining grassland receive further study and proper treatment.

Approximately half of the world's total land area can never be cultivated, for much of the desert has no water, some areas of forest are too rocky, poorly drained or otherwise unsuitable, and vast acreages of grassland would be ruined by erosion if the sod cover were broken. It is important, therefore, to learn as much as practicable concerning use of these lands for other purposes.

We have no assurance that our present methods of handling our western plains are those that will result in maintaining an unimpaired resource. As a matter of fact, the severe test to which the prairies have been subjected during the recent cyclic drought would indicate otherwise. Various signs have pointed out that many

U. S. Bureau of Biological Survey

AN ALBINO BISON CALF

IS A RARITY THAT WAS REGARDED WITH RELIGIOUS AWE BY THE PLAINS INDIANS. NATIONAL BISON RANGE, MONTANA.

U. S. Department of Interior

MULE DEER WERE FOUND

ON THE GREAT PLAINS WHEREVER PATCHES OF WOODS AFFORDED SHELTER.

areas have been seriously damaged by unwise plowing or overgrazing and that a radical departure in methods of handling must be instituted. Otherwise, great tracts of grasslands will revert to semidesert that will require impossible lengths of time for rehabilitation. Possession of a large check area that will be allowed to remain in its natural condition would be a continuing standard against which it would be easy to establish divergence of similar grasslands under economic use. Adoption of new methods of use would be in order if agricultural or grazing areas showed indications of excessive damage. The presence of such a check area also would make it possible to apply new methods and desist from old ones before extensive damage made it obligatory to use costly means for rehabilitation.

The great cereal-growing and grazing areas of central North America were originally grassland, supporting a large animal community characterized by many of the best-known large mammals and birds and many rodents and small carnivores, as well as reptiles and invertebrates. Its original life has largely been destroyed without adequate study, from the standpoint of either pure or applied science. Results valuable to the general sciences of paleontology, geology, geography, botany and zoology, and especially to modern ecology could have and even now can be obtained. Fortunately, representatives of all the species of animals (except bighorn) are still available for research purposes.

It is an ideal habitat type in which to study biotic interrelations, fluctuations in abundance of animals and other basic principles. There is need for checking the philosophical doctrines of biology by observations in nature. Very little work of this kind has been done and observations lack continuity. The various doctrines of biology, past and present, such as natural selection, sexual selection, emergent evolution, etc., doctrines concerned with the changes in abundance of animals, involving theories of immunity, disease, competition, sunspots and favorable and unfavorable weather or radiation conditions, biotic potential and environmental resistance, have never been checked by continuous observations in nature. Experimental work intended to throw light on these questions, especially those concerned with abundance, has not been guided by the relations of the animal in nature but rather by the dicta of physics and chemistry or even the operation limits of commercial apparatus.

Continuous quantitative and qualitative observations of organisms in nature in correlation with the surrounding physical conditions, especially their fluctuations, should in itself form a basis for important discoveries. Theories may also be developed. These may be experimentally tested when a suitable foundation

A. A. Allen

SANDHILL CRANES

SIMILAR TO THIS FLORIDA CRANE, NESTED IN SLOUGHS. NOW THEY ARE UNCOMMON MIGRANTS OVER THE PLAINS AREA.

has been laid. The study of the complete biotic community should add much to our knowledge of interactions.

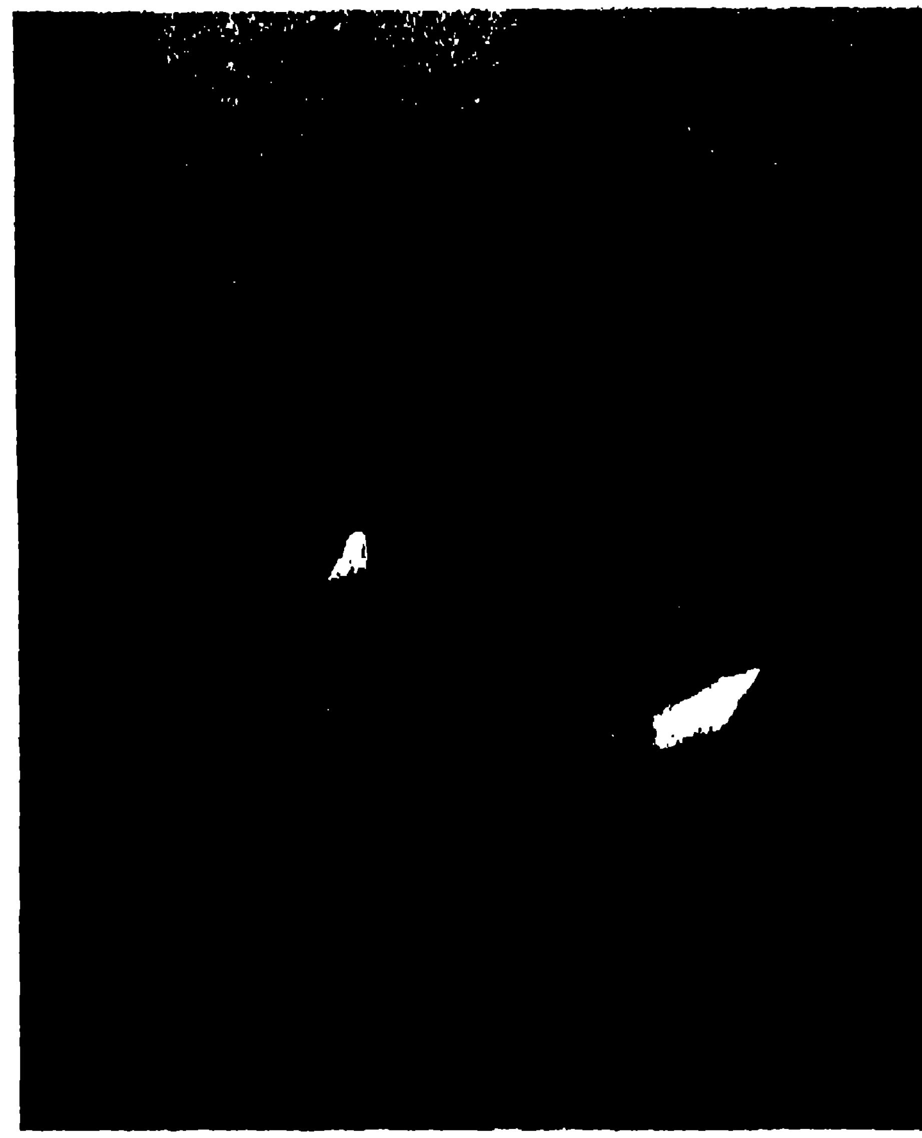
Grassland is an excellent field of scientific study for the following reasons:

1. It affords full visibility of most important animals and plants.
2. The life histories and life span of the dominant plants is about one-tenth that of forest trees, which greatly facilitates observation.
3. Although there is great ecological interest, much less research of this kind has been done here than in the forest.
4. There is a close relationship of these problems to agriculture.

Scientists have long been interested in the study of nature from the standpoint of plant and animal communities, the physiographical and competitive relations of their constituents, and similar matters. This field of knowledge has important bearings on various other scientific and philosophical questions.

The Great Plains have figured extensively in our history both in colonial times and during the period of westward expansion. Although the area proposed for establishment as a grasslands national monument is north of the old main travel route, the Oregon Trail, it is nevertheless typical of many of the high plains over which the colonists made their way. Much of the north and south travel from Forts Kearney and Niobrara in Nebraska to the Black Hills went through the area. The early stage route from the North Platte River through Buffalo Gap to Deadwood traversed this country crossing the Cheyenne River at a ford south of Buffalo Gap.

It is certain that there will be considerable public interest in a restoration of the prairie with its vegetation and fauna. It is not likely that the general public would want to stay in it for long periods of time. The landscape and its plant and animal communities are not sufficiently diversified to hold unspecialized interest.



U. S. Department of Interior

CANADA GOOSE

MANY CANADA GEESE NESTED IN THE PONDS OF THE GREAT PLAINS AND ALONG THE RIVERS.

Herds of the larger mammals, however, as well as the numerous species of prairie birds, would be certain to attract large numbers of the public and it is undeniable that the landscape has an appeal peculiar to itself. It makes a tremendous impression, similar to the effect created by unlimited ocean or other vast expanses. As Van Dyke says:

> How often have we wondered why the sailor loves the sea, why the Bedouin loves the sand! What is there but a strip of sky and another strip of sand or water? But there is a simplicity about large masses—simplicity in breadth, space and distance—that is inviting and ennobling. And there is something very restful about the horizontal line. Things that lie flat are at peace and the mind grows peaceful with them. Furthermore, the waste places of the earth, the barren deserts, the tracts forsaken of man and given over to loneliness, have a peculiar attraction of their own. The weird solitude, the great silence, the grim desolation, are the very things with which every desert wanderer eventually falls in love.[2]

[2] "The Desert," pp. 18–19.

FORTY YEARS OF SOLEDAD

By Dr. THOMAS BARBOUR and HELENE M. ROBINSON[1]

MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD UNIVERSITY

ZOOLOGISTS, as well as botanists, have visited Cuba in numbers to work at the Atkins Institution of the Arnold Arboretum at Soledad, Cienfuegos, Cuba. Composed of a biological laboratory, a dormitory and over 200 acres of cultivated land, the garden contains plant material from the whole tropical world. Close cooperation is being maintained with the biology department of Harvard University in this work.

The station has its origin in an experimental garden established in 1899 by Mr. Edwin F. Atkins on his sugar plantation in Soledad. Mr. Atkins left Boston as a young man to take charge of his father's business interests in Cienfuegos, now over 70 years ago. He acquired land from time to time and by the period of the Spanish American War had one of the most modern and progressively managed sugar estates on the island, an estate on which, to this day, the workers are not a floating population but a group of neighbors and loyal assistants, depending on the management for advice and help, generation after generation.

After the Cubans won their independence, Mr. Atkins became interested in the possibility of raising a better variety of sugar cane, as well as temperate zone vegetables and plants. He consulted Professor Goodale of Harvard. They, with Professor Oakes Ames, worked over the proposition and, in 1899, set aside eleven acres of land as an experimental garden. Mr. Robert M. Grey, an accomplished plantsman and horticulturist, went down to Soledad and, with Mr. Bohnhoff, laid out trial beds for vegetables and started experiments in hybridizing sugar cane to produce canes resistant to the diseases which beset most of the local varieties, and to contain a higher sugar content.

It was here that the first potatoes were grown in Cuba. As a result of Mr. Grey's industry and tireless endeavor, it was found that many of the vegetables enjoyed in the temperate countries can be raised in the dry season on the island. As time passed other experiments were undertaken: grasses for richer pasture, and the importation and hybridization of fruit trees, ornamental trees and shrubs. No segregation of species or families was attempted, for the garden was small. However, as time went on and more land was needed, Mr. Atkins and, later, Mrs. Atkins and Mr. Claflin gave additional acreage, until now the garden comprises 221.63 acres. Dams have been built to form ponds and reservoirs, not only for the storage of water for use in dry seasons, but also to allow the cultivation of water plants. Here you will find, for instance, many species of lilies, lotus and papyrus and, along the banks, bamboos and other grasses.

The garden grew and flourished for a score of years until, eventually, Mr. and Mrs. Atkins decided that the establishment could be made more useful and of greater value to science if a biological laboratory were built so that botanists and zoologists could live and work, undisturbed, near the garden. In 1924 Harvard House was built, plans for which were drawn by Mr. C. A. Coolidge. It is a low, cool stucco building to the west, between the garden and the Central. Here is a laboratory well stocked with microscopes, glassware and equipment, a dining room for the scientists and a wide, shady porch. Mr. Sturrock and Mr. Walsingham live here.

In the summer of 1932 the Cuban Sugar Club was obliged to discontinue their organization at Central Baragua and offered to loan their collection, materials, records, equipment and furniture for use at Soledad, with the understand-

[1] Photographs not otherwise credited taken by David Sturrock.

ing that if they reorganized within a period of five years this would be returned to them and, if they did not do so, it would become the property of Harvard University. This equipment and the collections have been of great value and usefulness. While every one regrets the discontinuance of the excellent work the Cuban Sugar Club was doing in basic research along various lines, it is a source of great satisfaction that they considered Soledad as the depository of their valuable possessions.

Mrs. Atkins, whose interest in the garden has continued during the entire period of its existence, provided the equipment to store conveniently a Cuban herbarium comprising material secured not only in the garden but from the whole Soledad region, including the Trinidad Mountains. Professor John G. Jack, of the Arnold Arboretum, made many collecting trips over a good part of the Province of Santa Clara and with the aid of numerous students a first-class local herbarium is kept at Harvard House, conveniently arranged for consultation. This material has been of great benefit to the many entomologists who have been interested in determining the food plants fed upon by the species which they were studying.

Last year a dormitory, Casa Catalina, was built. It is situated between Harvard House and the garden, overlooking the garden and with a delightful view of the Trinidad Hills beyond. There are two rooms with two beds each and a dormitory with eight beds. Two bathrooms, a storage room, which can eventually become a kitchen if desired, and a dressing room complete the interior of the building. Along the eastern side of the building is a wide porch. Chairs, stools and tables make it a pleasant and comfortable place to work and, since it stands on a slightly higher elevation than the surrounding territory, there is usually a cool, refreshing breeze.

In 1934, to make the administration of the garden less cumbersome, it was decided to join the Cuban establishment with the Arnold Arboretum in Jamaica Plain, renaming it the Atkins Institution of the Arnold Arboretum.

The Corporation of Harvard College

Photograph by J. H. Welsh

HARVARD HOUSE FROM THE EAST

REFLECTIONS OF GARDEN VEGETATION IN TWO PONDS

Above: A POND IN THE OLD GARDEN WHICH IS NOW BEING CONVERTED INTO A PALMETUM. *Below:* ONE OF THE NEWER PONDS SHOWING YOUNG PLANTINGS ALONG THE BANKS.

awards two fellowships a year to students of biology at Harvard who wish to study in the tropics. When possible, additional fellowships have been granted from the income of the Atkins Fund, but the expenses of the enlarged garden have increased so greatly that nowadays there are seldom funds enough for this purpose. However, one way or another, many students have been enabled to work at the station.

A lull in the activities of the laboratory came in 1931 when revolutionists became active in the vicinity and it was deemed inadvisable to send students from Cambridge. In this period, however, the regular work on the garden continued without interruption.

In 1935, Cuba, and especially Santa Clara Province, was visited by a terrific hurricane which destroyed many trees and ruined many others, as far as beauty and proportions were concerned. The younger trees and plants have come back remarkably well. In fact, a stranger visiting the garden now would not know that it had experienced a hurricane at all, but those who knew the place of old miss many landmarks.

When, a year or two later, Mr. Grey retired and Mr. David Sturrock went to take over his duties, he and Mr. Walsingham, the assistant superintendent, decided to divide the garden into sections, devoting each section, so far as possible, to a specific family of plants. This is slow work and not all the garden has been arranged as yet. For instance, the portion set aside for a nursery for newly received plants was a field of sugar-cane last year. The Ficus collection has not yet been segregated, though a large area is so marked on the map.

A few years ago cattle grazed in the southwestern part of the present garden. This area consists of limestone outcrops which are so broken and worn that the cattle made their way through it with difficulty. Until recently this was untouched, but Mr. Sturrock saw the possibility of using these wild, craggy places for succulents, and "Utah" and "Arizona" were started. Here there is to be found an enormous number of species of cactus and euphorbia. "Arizona" is laid out on the side of a hill at the top of which is built the facsimile of a porch of a native adobe hut, surrounded by colorful plants which are not only lovely to look at but attract many birds, butterflies and other insects. From this porch can be seen, in the distance, the Trinidad Hills. Nearer at hand, between "Arizona" and "Utah," lies the "Sebrucco," devoted to native trees and plants. Here trees and bushes have been left as they grew, the native orchids and airplants adorning them. Only the grasses and weeds have been cut away to make paths where one walks in deep shade along the banks of a little wild brook with ferns on every side. A brief climb brings one to a summer house deep in the woods, a wonderful place from which to watch the birds and other inhabitants of the shady forest.

Throughout the garden run grassy roads and paths, now few in number, but more of these are being made as the undergrowth is cleared away and new plantings set out. By means of these roads it is possible to reach the distant sections by automobile or on horseback, as well as on foot.

When new seeds are received, and they come from all over the world, they are handed to Emilio Pastor, who plants them in pots in the greenhouse, each pot carefully labeled and each package of seeds numbered and duly entered on cards, where a record is kept of the progress and final location of the plant in the garden. Duplicate sets of these cards are in the greenhouse and in Harvard House. As the plant grows it is passed along from the greenhouse to the shade house, then the nursery and, finally, to its particular section of the garden. Each transfer is entered on both sets of cards, and a moment in the office of the greenhouse or Harvard House will enable a worker to locate any desired species.

ABUNDANT GROWTH IN TWO SECTIONS OF THE GARDEN

Above: A CORNER OF THE CACTUS COLLECTION. *Below:* A GARDEN POND CHOKED WITH LOTUS. PALMS AND BAMBOOS ON BOTH SIDES.

In 1933 it was decided that the tropical greenhouses of the Harvard Botanical Garden in Cambridge had best be dismantled and the larger part of the material therein was moved to Cuba and planted out. Since that time the establishment at Soledad has constantly supplied laboratory material for the botanical department of the university.

Native birds abound at Soledad and migrants move through the garden in waves each spring and fall. Insects and mollusks swarm, and of the latter the variety is almost endless. The pools and streams are filled with native fish and turtles. Not far away are the mountains and seashore, and collecting trips to either locality may be arranged.

Many scientists, other than graduate students or officers from the biological department of Harvard, have visited the garden and have worked in the laboratory. Among the very welcome visitors have been Drs. James C. Needham and Liberty H. Bailey of Cornell.

Dr. Filippo Silvestrei, of Portici, Italy, has spent considerable time collecting there, and used the Berlese funnel for the first time in Cuba.

Most frequent visitors have been Dr. David Fairchild, of the United States Bureau of Plant Introduction, and Mr. Allison V. Armour, whose yacht, the *Utowana,* has been fitted for botanical exploration and has made possible the collection and transportation of many of the introductions in the garden.

Dr. Wilson Popenoe, of the United Fruit Company, has frequently been to Harvard House and, through his interest and the courtesies of the United Fruit Company, many additions to the Garden have been made possible.

CASA CATALINA, THE NEW DORMITORY

Dr. John G. Myers, who was for years at the Imperial College of Tropical Agriculture in Trinidad, went to the garden first while a student at the Bussey Institution at Harvard and, after going to Trinidad, has found it not only pleasant and convenient but profitable to make frequent trips for consultation with its officers and for research in connection with his work in the British West Indies.

Scientists in Cuba frequently stop at Soledad; sometimes for a day or two and often for longer visits. A number of these scientists have been recognized as collaborators by official appointment by

A STREAM IN THE SEBRUCCO
A BIT OF WILD FOREST INCLUDED IN THE GARDEN AND DEVOTED SOLELY TO THE PRESERVATION OF THE NATIVE FLORA AND FAUNA.

the Corporation of Harvard College. Their advice and cooperation with the officers of the garden have been of great benefit.

After Harvard House was built a guest book was started in which all workers were asked to register. In some instances this has been overlooked and the book is, therefore, not a complete record of the visitors to the garden. This book, the card indices and the labels on the plants bear witness to the many ways in which the garden is indebted to its benefactors. Each page tells of the hospitality of the residents of Central Soledad and the faithful services rendered by the house staff. The earliest entries testify to the interest and generosity of Mr. Atkins and his family, and those following show that this kindly feeling still continues.

Although this list is by no means complete there were, in the spring of this year, 125 workers listed, of whom 58 were botanists, 57 zoologists, 4 medical men and 6 visitors who assisted scientists. These workers represented 26 institutions in 8 countries. Naturally the largest number of workers came from Harvard. The United States and Cuba were most frequently represented. The garden is often visited by guests and tourists from Cienfuegos and vicinity, and it is considered one of the show places of the south coast of the country.

Heretofore it has been necessary to limit the number of workers at Harvard House because of the sparse accommodations, and preference has, naturally, been given to students and officers of Harvard University. Casa Catalina, with comfortable accommodations for at least twelve persons, now offers increased facilities and makes possible the use of the laboratory and garden by visitors from other institutions at any time of year. It is the hope of the officers of the Atkins Institution of the Arnold Arboretum that many such workers will avail themselves of this privilege.[2]

Perhaps the greatest contribution which the garden has made to science is the opportunity it offers to young scientists who, for the first time, are able to see the tropical flora and fauna in their natural state, to which they will have occasion to refer during their research and teaching. In the past, and in fact at the present time, many young teachers enter upon their careers with no first-hand knowledge of the tropics, and the fellowships which Harvard offers are eagerly sought for by graduate students each year. They return with enthusiastic reports of the work they have been able to do and the firm resolution to go back at the earliest possible opportunity. In fact, many have made return visits, and now it is hoped that more will take advantage of its facilities.

[2] Scientists wishing to work at Harvard House should make application to the custodian, Dr. Thomas Barbour, Museum of Comparative Zoology, Cambridge, Massachusetts. Inquiries regarding the garden and the laboratory should also be addressed to Dr. Barbour.

WISE INVESTMENT OF LEISURE

By Dr. EDWARD J. STIEGLITZ

GARRETT PARK, MARYLAND

LEISURE is something to *use*—or to *abuse*. Leisure denotes opportunity. It may be a priceless asset or a dangerous liability. Fleeting and transient, leisure eludes us if unprepared. Leisure once wasted or spent can never be regained. Conversely, leisure once wisely invested can not be lost; the profit becomes an integral part of the individual. Herein lies the difference between the wealth afforded by leisure and the wealth of material things, which must ever remain extraneous. Investing is often more uncertain and difficult than earning.

It is the application of leisure which determines, perhaps more than anything else, whether an individual be happy or unhappy and whether a community or a nation progress or retrogress. Work, no matter how depressingly routine or physically unpleasant, becomes justified by the major objectives: security and appeasement of hunger. Leisure has more subtle and variable objectives: the satisfaction of emotional luxuries. The physician views leisure as a therapeutic measure, potent in the amelioration of grief and dissatisfaction, but likewise fraught with menace if stupidly applied. The fact that a little does good never warrants the conclusions that more will necessarily do better. Like an active drug, leisure is a two-edged sword, and we must consider the dosage, toxicology, indications, limitations and methods of application before we may hope to obtain the maximum benefits. Furthermore, the application of leisure must be an individual matter; "one man's meat is another man's poison."

The wise investment of leisure requires intelligent thought. Formal academic education is not requisite, nor is great material wealth. The ability to think and the ability to do are not so limited. But the ability to think is amenable to stimulation and development. Such is the primary purpose of education, and the responsibility for inspirational guidance rests squarely upon scientists.

The problems of leisure are not limited to the individual. They intimately concern the welfare of the community, the state and the nation. It could be said that the most searching single criterion of good, bad or indifferent citizenship is what the citizen does with his leisure. Public consciousness has become increasingly aware of the hazards of idle urban youth misapplying leisure. Witness the growth of boys' clubs and private and public playgrounds—all prophylactic measures intended to reduce the incidence of those with enhanced criminal inclinations in the forthcoming generations. While heartily in accord with these objectives, one can not help but feel that they do not go far enough. Inspiration toward sportmanship and in the techniques of cooperative living lags far behind the unnecessarily over-emphasized encouragement of intense competition. The will-to-win, if over-zealous, leads but to defeat. Certain national organizations, such as the Boy Scouts and the 4H Clubs among rural youth, are vastly more constructive in that they foster definitely creative activity.

Superabundance of leisure or the abuse thereof has marked and initiated the decadence of cultures throughout history. Mankind is essentially a lazy animal and unless prodded by some urgent necessity is prone to revert to spending his existence in search of mere

physical pleasure. Peoples become soft when an excess of leisure leads to indolence. The fall of ancient Rome, the cultural absorption of the Manchus in China and the decline of the early Egyptian civilization all serve to illustrate this. Such decadence threatens America to-day. The threat is insidious and deceitful in that it is so thoroughly sugar-coated with pleasures. Nevertheless, the threat is very real, for the sum total of leisure is increasing rapidly and nowhere is this increase so rapid and significant as here in the United States. With leisure and privilege constantly increasing as a result of technological advances, changed social trends and the luxurious comforts of modern civilization, there has accumulated a tremendous surplus of time, energy and capabilities which we, as a nation, must learn to use if we may hope to avoid the pitfalls of ineffectuality. The physical conquest of the land is largely accomplished; the intellectual conquest of human capabilities is just beginning.

Many factors contribute to the increase in leisure available. The correlation of cause and effect is sometimes obvious, sometimes obscure when leisure appears as a secondary by-product. There is great variation in the proportionate role played by the various factors in increasing the leisure of different individuals. Some of the causative influences warrant mention. Mechanical aids to living, tremendously enhanced speed of transportation and communication and an abundance of food, fuel and clothing have reduced to a small residual minimum the time required for the routine mechanics of living. Where our forefathers split wood, made candles or cleaned lamps, took days instead of hours to travel, we "save" this time and let a thermostatically controlled automatic furnace warm us and cheap power and light transport us. We have this time—but do we really "save" it? No—it is largely wasted.

Leisure is no longer limited to the well-to-do. Unemployment, the shortened working week and shortened working day all contribute to the increasing national leisure. It is no longer the poor who support the rich, for modern "isms" require the rich to support the ineffective poor. Idleness is supported by taxing the workers. By decree or by legislation, enkindled by the force of numbers rather than intelligence, the fit and useful are made to enhance the survival of the unfit. Such transgression of the natural laws of biologic progression can lead but to recession of the race of man. The politically motivated vicious emotional appeal to the herds of unemployed voters is through the cry of "underprivilege," ignoring the obvious truth that they, *en masse,* are in fact overprivileged!

Leisure must be earned to be appreciated. It must be appreciated to be used wisely. The stupid, vicious or wasteful expenditure of leisure may do immeasurable harm to the individual and to the state. Leisure is a dangerous force if uncontrolled. No rational mind would advise giving a child fire for a toy. Yet, by sophistry and eloquence "the more abundant life" is to be made available to the backwoods hill-billy and cheap electric power is to bring luxury to those too lazy to catch their own fleas. There is already an excess of leisure there. Concrete dams and electric power will not inspire thought in such indolent beneficiaries. Gray stone can never replace "gray matter."

The continued increase in longevity which has been so notable in the past fifty years is a less conspicuous, though very significant, factor in augmenting leisure. In 1900 the life expectancy at birth was but 48 years, in 1920, 54 years, and for 1940 it is estimated that it will be 65 years. Both the total and proportionate number of elderly people in the country have increased tremendously, and this shift in population age is con-

tinuing. In 1900 but 13.7 per cent. of the population were over 45, whereas to-day 20.2 per cent. have reached that approximate middle point of life. The percentage of those past 65 has risen from 4.1 per cent. in 1900 to 6.3 per cent. to-day. The consequences of this fundamental shift are legion and far-reaching. Urgent and unanswered problems arise in sociologic, economic, medical and psychiatric fields. Geriatrics in its broad sense is no longer largely of academic interest; it clamors for practical attention.

With aging come more leisure and new problems. The questions involved in the investment of leisure vary greatly with age. In childhood and early youth, leisure is normally employed in the release of surplus physical energy. Sports and games consume this excess effectively and simultaneously contribute to the development of vigorous bodies, quick wits and cooperation with playmates. After adolescence the utilization of leisure involves more complex interests; sex introduces music and literature in a new light, ambitions become more urgent, and curiosity often crystalizes. Dancing and reading compete with sports for leisure time. During the fruitful years of full maturity, leisure is most usually greatly limited. Here the concerns of everyday life, the necessity to earn a livelihood, the mating urge, the consequent responsibilities of rearing a family and the intensely competitive struggles for success leave but little time. What there is available is usually employed to further some one or more of these primary drives: golf "for business reasons," bridge to assist in the social "ascent," watching sports for physical rest and pure relaxation.

With advancing years and the inevitable slowing of the pace, the problems of leisure come forth more and more into consciousness. Now, for the first time, the individual may realize the value of leisure and laments the wasted opportunities of the past. More frequently, however, the value of leisure remains wholly unappreciated, and the futile waste goes on. Perhaps there is a gradual change in the activities, but the character of "spending" is unaltered. Physical limitations begin to have their effect, although this is rarely admitted. The urge for physical activity diminishes.

After the peak of activity around forty, many people gradually become aware of an ill-defined uneasiness and vague sense of frustration. They wonder occasionally at the time they've squandered and may be perturbed by the thought that their time is, after all, limited. What has all their work led to? Ambition, once an intense driving force, is prone to become vicarious: hopes that the children will accomplish all that they, the parents, have left undone. The one generation "passes the buck" to the next; unable to fulfil their own ambitions they expect their sons and daughters to do infinitely better. Frequently far more is expected of the next generation than its capabilities warrant. Too much pushing may induce unjustified and precarious inferiority conflicts in the younger folks. Boredom, born of the sense of uselessness and frustration, begins its insidious undermining of morale and enthusiasm. These profound and significant emotional reactions appear so gradually and silently that they are rarely recognized. People are conscious only of vague dissatisfaction, for mankind is usually too afraid of intellectual or emotional nakedness to expose the reasons by honest thought. Innumerable rationalizations, involving "hard luck," "bad times" or "no opportunity," are created to gloss over individual shortcomings. Rare indeed is the honest and courageous individual who will admit to himself that his shortcomings are his own fault!

This uneasiness and sense of defeat

usually come earlier and more abruptly to women than to men. From 40 to 60 most men are at the peak of productivity in their chosen careers. By happy delusions of inflated importance, men avoid the necessity of thinking; they are "too busy." Women, on the other hand, are far more prone to introspection, even though it may not *always* be honest. For the majority of women the great increment of leisure in middle or early later life comes on quite abruptly. Usually sometime between 40 and 50 they are suddenly confronted with the realization that the children have "grown up" and are busy with their own lives, that with economic independence the household requires but a minimum of labor or supervision so that they have an excess of time on their hands. Mixed with a depressing realization of their relative uselessness, there is always dangerous boredom. The efforts to escape take many forms. These usually reflect the previous background, and are largely determined by the individual sense of values. Women do not fritter their time away in "uplifting causes" because they *want* to, but do so in desperate and frantic attempts to escape boredom and the consciousness of their own littleness. They are not happy. The great tragedy lies not in the fact of their unhappiness but in the fact that it is so unnecessary.

Unfortunately, this all too frequent period of dissatisfaction from maladjusted use of leisure commonly coincides with the feminine climacteric and menopause. As a result of lack of absorbing occupations the minor discomforts and symptoms become grossly exaggerated, and ill health becomes the *modus operandi* of obtaining the longed-for attention and inflation of the ego. Admittedly the feminine climacteric is a period of some turmoil, but the great bulk of "complaints" have little or no true organic foundation and proper investment of leisure is often more effective therapy than endless "gland treatments."

With increasing age the chronic degenerative diseases appear more and more frequently. Thus in men and women alike there are many whose leisure is rather abruptly increased by partial invalidism. Not actually ill, but subject to restraint by their physical limitations are hundreds of thousands of middle-aged and elderly persons. Their enforced leisure can be a precious gift to swell the fullness of their lives or it may be a sore trial. The observing physician soon realizes that after middle life there is more actual unhappiness and discontent among invalids and handicapped persons because of failure to know how to use their leisure than because of any physical discomfort or distress. The majority are totally unprepared and helpless; existence often becomes a pathetic attempt to "kill time." The weaker personalities react to restrictions by hypochrondriac depression or neurasthenic emphasis of every minor symptom. Those who enjoy ill health are the daily curse of their families, friends and physicians. Stronger, more virile personalities bitterly resent their physical limitations and chafe and fret to their own detriment over the necessary restraints. It has been said that to prescribe retirement to the active, ambitious worker is tantamount to signing his death certificate within the year. This is often sadly true, because so few are prepared to live beyond the limits of middle age. The "one track mind" with a single interest is prone to crippling traffic tieups when some illness blocks that single activity. Multiple tracks permit re-routing of traffic; accessory interests allow the zest for living to withstand many accidents.

Increasing longevity makes the practical problem of how to enjoy life full of leisure, though limited by age or illness, a very common one. The years of harvest, when the fruits of preparation and of labor should be gathered, come earlier

to some than to others. They may arrive silently and so gradually that their coming is almost imperceptible, or abruptly and dramatically as a result of sudden illness or accident. Senescence is insidious, but inevitable with long life. The urgent problems arise with those whose enforced leisure is a sudden acquisition. In either type of instance the vexing problems arise only as a result of unpreparedness. Anticipation and foresight eliminate the common difficulties. Foresight requires no specialist's training, but only intelligence.

Education, which is preparation, has not kept pace with the changing social order and has made no provisions for the significant increases in longevity and leisure. Forty years ago, when the average life expectancy at birth was but 48 years and leisure was rare and limited to the wealthy, it sufficed that education prepare the boy or girl for the competition of adult life. In the intervening twoscore years, little has been added to this objective. The increasing complexities of civilization and the tremendous forward strides of the physical and biological sciences have increased the fund of technical knowledge necessary for the professions, and advanced university education has stressed the importance of creative thinking in research. But neither parents nor teachers have taken cognizance of the necessity of preparation for old age. It has been assumed with complacent smugness that the adult would learn how to grow old gracefully and happily without training or aid. Unfortunately, the majority do not learn this spontaneously. The time has come when educators have need to reconsider their curricula. Preparation must ever precede accomplishment.

For the wise investment of leisure only four requisites are necessary. Preparation, thought, and appreciation or enthusiasm, have already been mentioned. Material wealth is not needed; the riches of leisure are available to all willing to make the effort to grasp them. The fourth requisite is honesty: honesty in self-evaluation. Fair self-appraisal of capabilities and limitations is difficult. Being subjective it involves conflict between instinct and reason; instinct prescribes inflation of the ego, reason forces us to recognize our limitations. The eonian antiquity of these struggles testifies to their intrinsic basis. Honesty in evaluating objectives or values is equally important.

Those objectives most highly valued give insight into character. Other factors such as capability and opportunity being equal, it is the sense of values which determine the direction of activity and often the intensity thereof. By a man's desires shall you know him. All mankind is motivated by the simple and fundamental objectives of safety, comfort and the normal biologic sexual and physical urges. But the "emotional luxuries," or secondary objectives, vary greatly. It is these which demark man from most other mammalian species. Bread alone does not suffice; such existence is barren. In some, the sense of values places the desire to be well thought of in the primary position. These become the snobs, the sanctimonious and exhibitionists who employ leisure in vain attempts at ego inflation. Others value as priceless the wielding of power. These either degenerate into politicians, idolizers of money, self-appointed guardians of others morals or frank sadists. A finer, rarer few value the sense of progress above all else: the yearning to leave behind them something which adds to the knowledge, spirit or strength of mankind. Among these are the poets, scientists, explorers, artists and true tillers of the soil. Their dreams are always colored by curiosity; their hunger for truth is insatiable. Their satisfactions are two-fold: personal sense of progress and the warmth of having served and earned.

These hungers and varying valuations

thus largely determine both vocation and avocation. These latter in turn effect the individual usefulness and value to humanity. Greater thought and attention to the development of finer values in youth can react only to the benefit of mankind. It must not be forgotten that example still remains the most effective teacher.

Health is relative. Few indeed are the individuals in any walk of life who are completely and unreservedly "normal." Many are those who assume complete health because of the absence of subjective distress. But negative evidence is never proof. There are many disorders which advance silently until sudden unheralded symptoms betoken irreparable tragedy. Those disorders that "hurt early" are taken care of; those that do not cause distress are usually sadly neglected when most could be accomplished. Too many people take seriously the facetious suggestions of Mark Twain: "It is never too late to mend. There is no hurry."

Modern living, and especially urban existence, is extremely artificial. Abnormally sedentary, confining and asymmetric, the routines of existence frequently do not require enough physical exertion to keep the body in good condition. Living tissue must be used to maintain its full vigor. The complexities of the modern social structure, the noise, conflicts and wearing responsibilities of civilization abuse the nervous mechanisms; fatigue is accumulative.

Leisure affords opportunity for constructive physical exercise, beneficial to the skeletal and muscular structures directly and to the nervous system indirectly through mental relaxation and sounder, more refreshing sleep. But this does *not* mean that the physically soft executive or clerk should rush from the thraldom of the desk into tennis or violent handball at the "gym." To do such would be dangerous and absurd. There are many kinds of fitness in human beings, and muscular fitness is but one of them. There is no more need for the white collar worker to be a giant of muscular strength, the big muscle men of the "Health Clubs" notwithstanding, than for a small passenger automobile to be powered with a motor built for a ten-ton truck. There is a happy and sane middle course. *Exercise must be appropriate to the individual.* This is particularly essential in the later years of life or in the presence of some defect of health.

Exercise should be fun. It should yield mental relaxation. The same muscular activity and stimulus may come from pleasant outdoor sport or from monotonous calisthenics. The ritual of early morning setting-up exercises is usually a ludicrous performance: they are either soon discarded as the newness of good resolutions wears off or become a tiresome chore conducted without enthusiasm or pleasure and yielding a minimum of benefit.

Sports are highly desirable activities, especially for those whose responsibilities are continuous and heavy. With characteristic perversity, however, it is these tired, serious and responsible people who are prone to shun sports as a "waste of time." Properly applied rest is conservation of energy for greater usefulness. Human physical and nervous energy and reserve are like a bank balance: with withdrawal in excess of deposits the balance invariably goes down. Relaxation, sleep and food are deposits; work and worry are withdrawals. The human mechanism has extraordinary credit facilities in physiologic reserves. We may borrow from ourselves by "running on our nerve" or relying on stimulants and mental whips and spurs, but *such overdrafts must always be repaid.* Whipping a tired horse may make him go faster, but in the end he is that much more exhausted.

To be sure, there are occasions when emergencies warrant the use of these credits, but it must never be forgotten that sooner or later these debts to the body are "called." There is no escape or short cut. Inflationary cancellation is not permitted by the laws of nature. Neither legislation nor wishful thinking by executive proclamation can alter these laws. It is infinitely harder to re-establish credit once it is destroyed than it is to maintain it. The physician sees many of these physical bankruptcies, and one and all beg helplessly for rehabilitation—too late.

Games, sports or athletic activities are to be included among the many sources of rest or "depositing" made available through leisure. They can afford mental relaxation as well as physical exercise. What sports are appropriate after the fourth decade and why? Is it necessary to limit play-time activities to "old man" games? To answer the second query first: No! It is not so much a problem of *what* is done as *how* it is carried out. Even the patient with severe heart disease can climb stairs—if he does it slowly. I know a physician of 77 who still "plays" tennis and a financier who hired an extra caddy to help push him up the hills on the golf course. Both these men, and many others, continued their favorite sports for many years beyond the usual rocking-chair age because they recognized their limitations and acted accordingly. Such honesty in self-appraisal is, unfortunately, exceptional.

The capacity to tolerate violent physical effort without detriment definitely depreciates with advancing age. This depreciation starts in childhood but is occult until the later years of life, when objective evidence often becomes staggeringly convincing. Therefore, those sports or games where the player's activity depends directly upon that of his adversary are best avoided. This includes such games as tennis, handball, badminton and the like. They offer tremendous temptations to overdo. Being intensely and directly competitive they permit of relatively little nervous relaxation. Daily work is competitive enough. Golf, archery, bowling and the like are less directly competitive and therefore less objectionable. But wisest of all are wholly non-competitive activities such as swimming, horseback riding, walking, gardening, fishing and sailing. These are wondrously relaxing to the harried mind. Mental efficiency distinctly increases as a result of such rest. No one can worry about the "market" or sickness while astride a spirited horse or with a fighting fish on the line! These sports are independent of any opponent, which is a great advantage. With passing years, it becomes increasingly difficult to find appropriate opponents whose leisure time, inclinations and skill coincide. The greatest advantage of this group of athletic activities, however, arises from the fact that the exertions involved are flexible and therefore adjustable to the individual. They may be indulged in strenuously or leisurely and lazily. Day by day the capacity for exertion may vary. The ability to vary the dose of exertion to fit the changing capacity of the individual greatly enhances the therapeutic value of such sports. All can be profitably indulged in until senility really equals infirmity.

There are obvious limits to the benefits of exercise. The amount required for health varies greatly with individuals. Some bodies need far more than the usual sedentary occupations afford, but others thrive upon a minimum. Therefore, no hard and fast rules or generalized suggestions are justified: the specific problems of each individual must be considered separately. It is important, however, to avoid excesses in either direction. Physical indolence of fifty weeks is no sort of preparation for

two weeks of violent and excessive exertion in vacation time. The habit of attempting to concentrate all outdoor and athletic activity into short holiday periods invites disaster. Far better is a little often than much all at once! Habitual and non-seasonal exercising is preferable to purely seasonal activity.

There has arisen a curious tendency to take our sports or exercise vicariously. The huge stadia of the colleges, the immense grandstands for professional baseball fields, the increasing popularity of ice-hockey all bear witness to the commercialism which feeds upon and fosters this tendency. Professional athletes receive compensation comparable with those of real artists of the stage and ballet. Apparently the popular appeal of such sport spectacles is based upon purely vicarious thrills—the thrill of combat without risk. Like lurid adventures and exciting pioneering through the pages of a book!

From whence sprang this habit of taking our exercise sitting down and watching others perform? It is not hard to find the origin. For several generations many of our schools and colleges have sold local loyalty and tickets to the games, and thrown in some so-called education as a premium. Football brings in money. These games are contests, not of wits, but of brawn between semi-professional athletes who no more represent the university than does the janitor corps. Presumably a collegiate or university education is intended to prepare the students so that they might get the most out of their lives and contribute more to the commonwealth. Those students who obtain such educational values do so in spite of athletics. To be compatible with common sense and the true objectives of education, collegiate or school athletic training *should develop skill in those sports which the students can enjoy after graduation.* To how many does an "All American" medal bring health and happiness in later years? The chant of "teaching teamwork and cooperation" is worn threadbare. Sportsmanship is a mental not a physical quality. Physical cooperation is hardly necessary for the college graduate unless he be preparing for a career in the WPA. And even then, he must lean upon his shovel alone.

The same general criticisms are equally applicable to high schools and "preparatory" schools. A few students are encouraged to become highly skilled in sports which will be of no possible good to them in later years. Instead of football, baseball, track and basketball being the "major" school sports, instruction in golf, tennis, riding, swimming and the like would be infinitely more profitable to the student body as a whole. The violent competitive games have a high expectation of injury and are known to harm the youthful growing heart. The profit of sports which can be indulged in for many years would be both physical and mental. The habits engendered in youth remain. The residuum of enjoying sport vicariously is hardly desirable. It nurtures an unfortunate trend toward passive amusement.

There are innumerable people who require to be amused during every leisure moment. Bored and unhappy, apparently they are actually incapable of diverting themselves alone. This is a sad commentary upon their abilities, originality and intellects. These people are the habitués of the movie theaters, night clubs and bleacher seats; they make advertising pay by listening to the banalities and quackery of radio, and fill the rolls of lodges and clubs. Gregarious to an extreme, they must depend upon others to supply all ideas and yet would be the first to deny this if taxed. Amusement is something wholly passive to them. The intellectual atrophy that

comes from disuse makes them strangely gullible and highly non-critical. They may make ideal citizens in a totalitarian régime, but are hardly competent to guide the destiny of a democratic nation. Yet they have this responsibility.

The passive intellectual indolence may be extremely asymmetric. There are many instances of conspicuously so-called successful men totally unable to divert themselves when some illness or accident prevents continuance of their usual occupation. When deprived of the one and only outlet for their energies, these unfortunates are acutely miserable with intense boredom. Their misery is rarely self-contained, for the instinctive gregariousness of this type compels them to share their discontent with all those about them. Much domestic friction arises from boredom.

An illustrative case comes to mind! A young woman, of the type which requires exogenous amusement, lost her position as typist during "the depression." Before many months she was in the physician's office with a long series of vague complaints for which no organic bases could be discovered. She remained well nourished and physically comfortable, living with her parents. But upon specific inquiry, she admitted frankly that she was unbearably bored and dreaded each morning as the forerunner of another hopelessly tiresome day. She complained of being friendless. Her ego sought escape from what was to her an intolerable situation by the solace of ill health. By deliberately and bluntly informing her of this conclusion, explaining why and making specific recommendations for the investment of her superabundant leisure, she was jolted out of this dangerous rut. She was told: "If even you can find nothing interesting in your own company, you must be tiresome indeed. People without friends are those who have nothing to offer in the way of interest. How can you expect others to find you interesting if you bore even yourself? Study and learn to make yourself interesting!" Three months later she was a markedly changed woman. Previously sullen, disgruntled and resentful, she had become vivacious and lived with a zest her parents had never known. She reported her engagement to be married!

There are many lives lived happily and usefully because leisure is wisely invested. In most instances such happy lives are not fortuitous; they are predetermined by preparation in youth. Usually such preparation is undeliberate and unconscious. Probably the most potent forces are those of the home environment and the example of the older generation. In households where the perennial question is, "What'll we do to-night?" or "Who is coming for bridge?" it is almost inevitable that the children will fail to develop initiative and become members of the great herd demanding amusement without effort. On the other hand, where the parents are sincerely interested in creative activity in their investment of leisure, the next generation can not help but develop active mental habits and thereby become far better and more constructive citizens.

It is in creating something that we obtain our greatest satisfaction and happiness. The antiquity of this urge or driving force in the ascent of man demonstrates the depth of its rooting. It probably arose contemporaneously with the earliest beginnings of curiosity. Curiosity, according to the splendid philosophies of Clarence Day, is the basic driving force which led mankind to the position of the dominant species. The satisfaction of curiosity resulted in the creation of tools. The desire to *use* these tools (both physical and intellectual) merges imperceptibly with the urge to create. The cave paintings of the stone age were hardly utilitarian and probably constitute the earliest evidence of

leisure activity. *Recreation* is, after all, derived from and linked to *creation.*

The urge or instinct to create comes early to the child of man. It is thus a basic desire, for biology has repeatedly demonstrated the validity of the dictum that ontogeny recapitulates phylogeny.

It is relatively immaterial just what is created. The choice is intimately individual and depends upon tastes, values, abilities, limitations and opportunities. But the satisfaction of sincere creative effort knows no limitations. It is not the acquisition of the article created which results in satisfaction, but the fact that it was self-made. For example, give a boy a hammer, some boards, nails and a saw and he will make a box which will yield far more joy than any fine piece of factory-made cabinet work, even though it fall apart before very long. His second box will be better, and therein lies his joy of feeling progress. Why do people knit? Not because the sweaters, socks or articles created are cheaper or better than those which they might buy, but because of the satisfaction of having made them themselves. The value of such investment of leisure is three fold: such activities contribute to physical health, intellectual growth and emotional happiness.

Creative activity in its broadest sense is unlimited in scope and potentialities. Its intimate relation to curiosity is fundamental. The satisfaction of curiosity results in the creation of new ideas and in the acquisition of new facts. It is perhaps redundant and unnecessary to note these relations, for study and science are inseparable and the prime motivation of the scientist is curiosity. The mentally indolent requiring passive amusement can never appreciate the intense and lasting satisfaction of discovery, of having added a bit to the vast sum total of knowledge. Research is creative whether it be conducted in the laboratory, observatory, library or the seas and mountains.

Thus it is that we can say that the wisest investment of leisure lies in creative activities. There are many who recognize the value of hobbies but fail to make this fundamental distinction between creative and non-creative hobbies. The satisfactions of the one are lasting and accumulative; the pleasures of the others are transient. There is an immense fund of pride in knowing or doing *any one thing well!* In discussing these concepts with many patients one often hears the bewildered complaint, "But what can I do? I have no talent!" This is rarely literally true, for creative activities possible to-day are truly innumerable. There is no more fundamentally creative activity than rearing children (creating character) and making a home. There are innumerable women who merely need to have the distinctions between a home and a residence made clear to them and they are happily busy. Too many American domiciles are "a garage with a bedroom and bath attached"! The most encouraging sign indicating that American culture can and will survive the present dangerous superabundance of leisure is the spread of the home work-shop and the many gadget magazines.

It is impossible to enumerate here all the possible creative hobbies. Creating music (in any form and with any instrument), drawing, painting, modeling, writing all cost next to nothing. Yet the dividends of satisfaction are tremendous. The author is frankly getting more pleasure from writing this than the reader is from reading it, for reading, unless part of a planned study program, is hardly a creative hobby. Wood-working, photography and gardening are slightly more expensive hobbies, for they use up supplies. But they need never be prohibitively expensive, for modesty in projects does not chill the keen pleasure of well-done work. Breeding and/or training animals such as dogs may become a source of financial profit over

and above the vital profit of satisfaction. Collecting is creative in the sense that the collection is self-created, even though the individual items are not. Collecting, however, has the limitation that it is prone to become expensive.

These, and many, many more, are activities for leisure moments which bring lasting satisfactions. Physical vigor, age, values, talents and interests will determine the choice. Enthusiasm is requisite, but it must not be forgotten that enthusiasm grows apace with the challenge of obstacles. It is important that some form of creative recreation be fostered and encouraged in every youth and maiden. Even though these interests may be dormant for years during the period of home building and the struggle for economic safety, the enthusiasm is readily aroused again in the later years of life when leisure is often obligatory. It is much harder to *start* something new after the fifth decade, but by no means impossible. If there is the back-log of interest and the honest evaluation and recognition of the desire, the leisure of old age can bring a wealth of joy. If there is no mental, moral and emotional preparation, the senile is truly sterile. All productivity is not merely biological.

Thus the responsibility for happiness in old age rests upon parents and teachers. Occasionally well-meant efforts at interesting the restless youth of to-day are embarrassing, but more often the rewards are more than worthy of the effort. There was the small boy whose fond and wise mother urged him to try to become interested in some hobby, such as collecting butterflies, moths, stamps or shells and suggested he search the town library for books to start him off. Great was her consternation when he informed her that he had found just the book, called "Advice to Young Mothers."

Growing old gracefully, happily and usefully is an art. This art needs to be developed and studied. Preparation requires forethought. In the coming years, there will be many more people than ever before faced with the problems of investing their leisure. Preventive medicine has expanded the average life span so that it is conservatively estimated that by 1980 more than 40 per cent. of the population of the United States will be forty-five or more years old. It is expected that nearly 15 per cent. will be sixty-five or over. There will be millions of old people and millions more whose activities will be limited by prolonged partial disability from controllable but not wholly preventable chronic degenerative disorders. Can these millions be equipped to utilize their leisure so as to get the full priceless value from their years of harvest and feel that they continue their usefulness? Or will they be burdened by the heavy yoke of boredom, ineffectuality and uselessness? The answer depends upon the preparation they receive in youth. And *now* is the time of their youth. The afternoon and evening of life can be made glorious and beautiful. The gain to the community is immeasurable: cultural values transcend economic measures. The physician interested in geriatrics and the degenerative diseases of late middle life sees the vivid contrast between the misery of boredom in the physically handicapped unable to create their own recreation and the fine courage and happiness of those who have learned to invest their leisure in creative effort.

CONTRIBUTION OF THE CHEMICAL INDUSTRY TO SCIENCE

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MUCH has been said and written during recent years concerning the contributions of science to industry. One is reminded often of the dependence of the electrical industry upon Faraday's discovery of the principle of the electric motor. All recognize the importance to the fertilizer and munitions industries of Haber's finding of a method of fixing the nitrogen of the air.

The time has been when the scientist might say with some of the purists of the last century that he hoped that his researches would have no practical value. This attitude is strangely similar to that of some of our artist friends, cubists, impressionists, etc., who paint purely for their own amusement and pleasure and have no interest whatsoever in pleasing others.

But irrespective of the wishes of individual scientists, science has contributed enormously to the growth and development of industry—in fact, the growth of modern industry is dependent upon the developments of science. It might be argued indeed, with considerable force that the greatest contribution of science to present-day civilization has been to make modern industry possible with all that this means to mankind.

However, I wish to consider now the other phase of this situation, namely, what has industry, and particularly the chemical industry, contributed to science?

In the first place, it should be pointed out that the chemical industry now definitely recognizes its indebtedness to science. The time has been, and not so many years ago, either, when this was not nearly as generally the case in this country as it is to-day. I belong to a small organization consisting of the directors of industrial research laboratories, such as those of the Bell Telephone System, General Electric Company, du Pont, Standard Oil, etc. I have been told by Dr. Jewett, charter member of this organization and head of the Bell Laboratories, that one of the principal reasons for forming this organization in 1923 was to make it more easily possible and convenient for the heads of research laboratories to consult with one another on ways and means of convincing the business heads of their companies of the importance to them of scientific research. To-day this is no longer necessary—bankers and industrialists are thoroughly convinced of the importance and necessity of scientific research. In fact, during the depression of the last decade the support of research by industry increased instead of decreased as might have been expected.

This support has been manifested in many ways. In the first place, industry has established its own research laboratories. According to a recent report of the National Research Council, there were 1,769 of these in 1938. To-day there are more chemists in the laboratories of industry than in those of educational institutions. Much important scientific research work is done in these laboratories; in fact, at least two American industrial laboratories have Nobel Prize winners in them. Reports of much of the work done in these labora-

tories is published in scientific periodicals, or presented before meetings of learned societies. All of this has added to the sum total of scientific knowledge.

Second, industry has supported financially much important research in scientific institutions and universities. The National Research Council reported last spring that industry was supporting 450 scholarships, fellowships and grants-in-aid in American universities and research institutions.

Third, many special chemicals have been prepared in industrial research laboratories and plants to be supplied without charge to investigators in universities, research institutes, hospitals, etc., to aid them in the prosecution of much fundamental research.

Fourth, industries have made available to university research workers their facilities for large-scale operations, often without charge to the investigator.

Fifth, industrial laboratories are often used for biologically and pharmacologically testing the new products of such investigators.

The support given by industry to research in universities and research institutions is affected essentially by the same factors as those that affect all other expenditures of industry. Industry has been defined by Webster as "systematic labor or human exertion employed for the creation of value or wealth." In the first place, industry must consider the probability or possibility of some return on the funds given in support of the research. This need not be considered in terms of an early return, but in keeping with the general purpose and function of industry it should contribute eventually to "the creation of value and wealth."

The possibility of return depends upon a number of factors, one of the most important of which is the patent policy of a university or institution. Industry is more able and willing to provide funds for research if the university research worker or the university may patent inventions and make these available or at least partially available to the industries which have aided them, provided, of course, the institution has first class investigators.

Another factor affecting the support of research by industry is the amount of advice and council on scientific matters that it obtains from the institution receiving grants from it. Still another factor is the amount of aid it may expect from the institution in training and providing first class investigators and helpers for its laboratories and factories.

Industry has been of enormous value to the scientific investigators of Europe. The support has been given liberally and in large amounts to enable scientists in universities and research institutes who are carrying on important work to continue their work. This has been possible to a very large extent because these industries may expect to receive special patent rights in return for the support given.

The important work of Windaus on vitamin D was made possible by large grants from German industries not only of money but of valuable materials and intermediates. Butenandt's splendid contributions to the elucidation of the chemistry of sex hormones would have been impossible without the enormous amount of help he received from a large German pharmaceutical concern interested in his work.

Similarly, Karrer and Ruzicka have been aided greatly by the Swiss chemical and pharmaceutical industry. In France the famous pharmaceutical and organic chemists, Fourneau and Trefouel, have been supported for years by a large French industry. It was Trefouel, you will remember, who with his biologically trained associates in the Pasteur Institute, Bovet and Nitti, was responsible for the discovery of the wonderful

chemo-therapeutic powers of sulfanilamide.

In this country the support given by industry to university research has been extensive, but on the whole has not been as great, at least in proportion to the wealth of the country, as in Europe. This is due partly to the policies of American universities concerning the disposition of their patentable discoveries. The proper disposition of such rights is a difficult problem. Universities are founded for the purpose of diffusing and increasing knowledge. Scientific investigators in general, and particularly those in universities must be interested primarily in these same ends. It is very important to the future welfare of the universities that its scientists hold these primary objectives ever before them, and that they feel free to publish their findings to all the world.

On the other hand if American universities are able to work out a policy under which their primary ends are not sacrificed and at the same time are able to offer those industries which contribute to their research program the chance to receive some reasonable return on the money offered, much important fundamental scientific work may be done which would otherwise be impossible. To-day with the ever decreasing return on endowments and decreasing contributions to universities from wealthy philanthropists the solution of this problem would seem particularly important. From the point of view of society as a whole it would seem desirable also that this problem should be solved satisfactorily and soon, if we do not want all of our universities to be dependent upon government money for their support, or to sacrifice their research programs. Much good constructive thought is being given to the problem to-day both by the industries and the universities, and a satisfactory solution will surely be found.

During the rest of this paper I wish to describe something of the research work supported by one American chemical industry with which I am connected. This industry has its own research laboratories for chemical, physical, bacteriological, pathological and pharmacological research, and helps support scientific work, including clinical studies in a number of universities, research institutions and hospitals located in various towns and cities from one end of this land to the other. Most of the problems on which work is being done in the laboratories of this industry are carried on, at one stage or another, in cooperation with investigators in outside research institutions.

In 1930 it was suggested by Professor Chauncey Leake, of the University of California, that unsaturated ethers such as vinyl ethyl ether ($CH_2 = CHOCH_2CH_3$) and divinyl ether ($CH_2 = CHOCH = CH_2$) might be good general anesthetics. This assumption was based on their chemical relationship to two successful anesthetics, ethyl ether ($CH_3CH_2OCH_2CH_3$) and ethylene ($CH_2 = CH_2$). A number of unsaturated ethers were made by known methods and tested in Professor Leake's laboratory. The most promising of these was found to be divinyl ether. Methods were developed in our laboratories for preparing this ether in a pure state. It was soon found that the product was unstable, forming aldehydes, acids and polymers on decomposition; it was necessary to find a way to prevent this. Success was achieved finally by the addition of a small amount of a relatively non-toxic, non-volatile oxidation inhibitor to the ether. Difficulty was caused because of the tendency for ice crystals to form on the anesthetic mask as the ether was administered, interfering with the normal flow of air to the patient. This was due to the cooling effect produced by evaporation on the divinyl ether, which boils at 28.3° C. This obstacle to

the use of this ether as an anesthetic was overcome by the addition of 3.5 per cent. alcohol to it. The new anesthetic mixture of divinyl ether, alcohol and inhibitor was named Vinethene. Its value as an anesthetic for dogs was studied extensively by Professor Ravdin and his co-workers at the University of Pennsylvania. After satisfying themselves as to its safety, they introduced it into their clinics for humans. They were much pleased with the results obtained. Pharmacological work on the product was done also in California and in the Merck Institute in Rahway. The use of the product spread to various hospitals in this country and Vinethene was accepted by the Council on Chemistry and Pharmacy of the American Medical Association. To-day it is used as an inhalation anesthetic for short operations in all parts of the world. Incidentally, it may be mentioned that it has proved particularly useful to military surgeons for short operations in field hospitals.

A number of years ago, we collaborated with one of the veterinary schools in a search of anesthetics and analgesics for large animals. In the course of this work we became interested in curare. Curare is a crude pitch-like mixture which is made by South American Indians for use as a poison for the tips of their arrows. Different tribes of Indians make their curare in different ways and it is not always made even in the same way by the same tribe. For this reason curare varies enormously from one lot to another. Until very recently it has been used only experimentally by biologists and pharmacologists in order to produce a unique and characteristic paralysis of the muscles of animals into which it is injected. This effect is due to its action on their motor nerves. Within recent years the medical profession has found a limited use for a biologically standardized preparation of curare of high potency in the treatment of tetanus, convulsions from strychnine poisoning and spastic paralysis. Due to the difficulty of obtaining a dependable supply of potent yet relatively non-toxic curare and because of the variability in its composition, the rational use of curare for therapeutic purposes appears to hold very little promise.

During the course of our studies of curare it was found by a California investigator that an extract of the beans of *Erythrina americana* had a curare-like action. This observation was checked in our laboratories and an effort was begun to isolate the active principle. Eventually, this was found to be a mixture of two stereoisomeric alkaloids which have been named alpha and beta-erythroidine. In view of the activity of the alkaloids of *Erythrina americana* it was decided that other species of *Erythrina* beans should be extracted and the active principle isolated and pharmacologically studied. Accordingly, a large number of species of *Erythrina* were obtained from South and Central America, the Philippines, Africa and other parts of the world. Several new alkaloids have been isolated from these species; all of these appear to be related chemically to erythroidine. All of them, also, have some curare-like action but, curiously enough, beta-erythroidine, itself, seems to be the most satisfactory for therapeutic use. It is being investigated now in a number of medical clinics with promising results. It has the advantage over curare that it is effective not only on parenteral injection, but also when taken by mouth; but most important of all, it is of known and constant composition and does not vary in activity from one lot to another as does curare.

I wish to speak, finally, of the interest in the vitamins which we have had in recent years, and of our work, in collaboration with a number of outside investigators, with these fascinating essentials of the animal diet and, in many in-

stances, plant diet as well. First, I shall speak of vitamin B_1.

It will be recalled that in 1897 the Dutch investigator, Eijkman, working in Java showed that a paralytic disease of fowls resembling human beriberi could be cured by the addition of rice polishings to their diet. Later other scientists showed, definitely, that human beriberi is due to a deficiency of some substance in the diet that is found in rice polish, yeast and meat and that it may be cured by feeding such foods. This dietary constituent, which has been termed vitamin B_1, was isolated in 1926 by Jansen and Donath, who were also working in Java. In 1934 Dr. R. R. Williams and his co-workers in the United States published a new improved method of isolating the vitamin, and early in 1935 Williams offered a tentative chemical structure for it. He had begun his work on vitamin B_1 in the Philippines almost twenty-five years earlier. This work has been continued since that time in spare moments taken from the requirements of an active professional career. Help for the continuation of the investigation was obtained from a number of sources, including university departments and philanthropic foundations.

In 1935, Williams requested help from us, first in the preparation of larger quantities of vitamin B_1 for use in studying its structure; second, by scientific collaboration in his study of its structure and eventual synthesis, and finally by making biological assays which were necessary for the success of the investigation. As a result of the cooperation into which we entered, the structure of the vitamin was established definitely and it was synthesized in our laboratories in 1936 by Williams and Cline. Incidentally, it was synthesized also by Todd and Bergel in England and by Andersag and Westphal in Germany at about the same time.

This synthesis has made it possible to make vitamin B_1 in large quantities and to sell it for a few dollars a gram. Previously, it had cost several hundred dollars a gram to produce it from rice polish, which is the most satisfactory natural source. This vitamin is now used in increasingly large quantities for man and animals in the cure and prevention of beriberi, neuritis of various types, cardiovascular disturbances due to certain dietary deficiencies and for loss of appetite. Recent studies have shown that vitamin B_1 deficiency is more prevalent in the United States than has been supposed.

Also vitamin B_1 is of value for the stimulation of the growth of plants and particularly of their roots. It appears probable that considerable quantities of it will be used in horticulture.

Another vitamin on which we have done a large amount of work is vitamin B_6. The existence of this vitamin was first postulated by György in 1934 who showed that rats which had plenty of the then known dietary constituents, including vitamin B_1 and B_2, developed characteristic lesions of the skin. They could be cured by the addition of rice bran, yeast or liver to their diet. In 1937 Keresztesy and Stevens in our laboratories, Lepkovsky in California, György in Cleveland and Kuhn in Heidelberg reported the isolation of pure vitamin B_6, or Factor 1, as it is called by some. In 1939 the structure of the vitamin was definitely established and its synthesis was accomplished in our laboratories. It was synthesized also by Kuhn in Germany.

As has been mentioned, a deficiency of this vitamin in the diet of rats is associated with a severe dermatitis. It has been found also that a severe type of anemia develops in puppies when vitamin B_6 is the only missing component in the diet; this anemia may be cured by the addition of this factor to their diet. Investigators in many parts of the world

are studying its value in the treatment of human beings.

Yet another vitamin with which our laboratories have been concerned is vitamin E. About fifteen years ago several investigators began to suspect the existence of a specific vitamin required for normal fertility, at least in the rat. The positive existence of such a vitamin, termed vitamin E, was proved by Herbert Evans and his co-workers at the University of California. In 1936–1937 Evans, and his associates, the Emersons, reported the isolation of three comopunds from the oils of the germs of various seeds and grains which had the properties of vitamin E. These compounds were termed alpha, beta and gamma-tocopherol. They were all oils which had hydroxyl groups in their molecules and which formed crystalline allophanates. The most active of these was alpha-tocopherol. It may be isolated fairly readily from wheat germ oil or cottonseed oil.

In 1936 Evans enlisted our cooperation in the preparation of larger quantities of alpha-tocopherol than could be made very well in an academic laboratory. This was required first for chemical studies of the structure of the vitamin, and second for further investigation of its physiological action. Studies on the structure of alpha-tocopherol were begun, in 1936, in our laboratories. In 1937 Fernholz reported from these laboratories that it was probably a derivative of durohydroquinone and early in 1938 published the first correct structure of the vitamin. The correctness of this structure was confirmed by Karrer, John, Todd, Smith and others.

Very early in 1938 we enlisted the cooperation of Lee I. Smith at the University of Minnesota in the synthesis of alpha-tocopherol. This was done partly because Fernholz had accepted an appointment to another laboratory, and partly because Smith had had a great deal of chemical experience with durohydroquinone and related compounds and was in a position to make almost immediate contributions to the synthesis of the vitamin. He accomplished this in a relatively short time. He has synthesized it, also, in a number of other ways. In addition to this, it has been synthesized by a number of European investigators, particularly Karrer and Todd and their co-workers. The other two tocopherols have been shown to be the next lower homologues of alpha tocopherol, having only two methyl groups on the benzenoid nucleus.

The therapeutic value of alpha-tocopherol has yet to be definitely established, but there are indications of its value in the treatment of certain types of abortion in man and animals. It has been shown recently also that deficiency of vitamin E in the male is associated with certain degenerative changes in the testicles. In addition, lack of the vitamin in the diet produces certain types of muscular dystrophy suggesting its possible value in the treatment of some types of muscular disturbances in the human.

Finally, I wish to say something about vitamin K, the latest of the vitamins to yield the secret of its structure to the chemist. About ten years ago the Scandinavian investigator, Dam, found that the blood of chickens clotted very slowly if their diet was deficient in a specific, fat-soluble substance. The presence of this substance in fish meal and alfalfa was demonstrated by several research workers. This was done by feeding these foods to chickens whose blood clotted slowly because they were fed a diet deficient in this factor. This factor has been named vitamin K.

In 1936 Almquist in California reported the preparation of a concentrate of vitamin K from alfalfa of which 2 milligrams formed a sufficient supplement for one kilogram of feed.

Last year Karrer in Switzerland and Doisy in this country announced the isolation of pure vitamin K in the form of an oil from alfalfa. Doisy called this vitamin K_1 since he was able to isolate another compound with similar action from fish meal which he termed vitamin K_2. In this work Doisy was aided greatly by one of the great pharmaceutical houses, Parke, Davis & Co.

Based upon its absorption spectra and on certain other properties, Doisy concluded that vitamin K_1 might be a quinone. Soon after this Almquist, with whom we had cooperated by supplying him with vitamin K_1 extracts from alfalfa, showed that phthiocol, a product which had been isolated from tubercle bacilli by R. J. Anderson, and of known chemical structure, had vitamin K activity. A number of research workers quickly came to the conclusion that vitamin K was a napthoquinone derivative. By a brilliant series of experiments and studies in several American laboratories, the structure of vitamin K_1 was definitely determined in the summer of 1939.

It was synthesized by Doisy, Almquist and Fieser. Fieser entered this field as a result of his considerable experience with quinones and particularly naphthoquinones. This had led him to conclude that vitamin K_1 was a naphthoquinone derivative. Soon afterward, he came to the conclusion that the vitamin had the determined structure and he decided to try to synthesize it. His synthetic product was tested biologically in the laboratories of the Merck Institute and found to be active. It was compared with a sample of natural vitamin K_1 for the preparation of which he had developed a novel and easy method of extraction from alfalfa. The synthetic and natural vitamins were found to be the same.

It is of interest to note that a number of other naphthoquinones have vitamin K activity but, more curious, that one of these, 2-methyl-1, 4-naphthoquinone, is more active than vitamin K_1 itself. As far as we know, this compound does not occur naturally. Some synthetic compounds chemically related to the other known vitamins have an action similar to these vitamins, but in all other cases the natural vitamin, prepared either from natural sources or else synthetically, is more active than any of the synthetic substitutes.

Although vitamin K has been known only a comparatively short time, it has already been found valuable in medicine for the prevention of certain types of bleeding. In a number of hospitals it is given pre-operatively to certain patients who show low prothrombin levels in the blood, since under these conditions the blood clotting time is slow. Also, it is being given to new-born babies who often suffer from too slow coagulation of the blood, due to deficiency of vitamin K. Much additional work is being done in an effort to determine definitely the place of this vitamin in therapy.

In conclusion, I wish to call attention again to the benefits that science has received through its cooperation with industry. I hope that further and extended cooperation of this type may be possible in the future, not only for the benefit of science and industry, but also for the benefit of society in general.

DISTRIBUTION OF FRESH-WATER FISHES IN THE INDO-PACIFIC

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THE belief in lost continents is one that persists in the minds of many people. Individuals without the slightest knowledge of geology, botany, zoology or anthropology—in fact, without specialized knowledge of any kind—cling to their beliefs in fabled Atlantis or the still more mysterious and shadowy continent of Mu.

For many generations people have been puzzled by problems in the distribution of plants and animals, including man himself. In addition, the buildings and other structures of prehistoric time, the artifacts, customs, myths, legends and cultural developments in many parts of the world have presented innumerable vexatious and well-nigh insoluble questions to perplex and mystify the learned, as well as the ignorant.

To these puzzles there have been and still are all sorts of reactions, but two stand out far beyond all others. One is to trace the origin of all culture or cultures and all human achievement back to Egypt. The other is to stick a large and convenient land mass into the middle of the Atlantic, the legendary Atlantis, or over a large part of Polynesia, the imaginary lost continent of Mu.

Many a student of plants or of some particular group of animals has been so sorely puzzled by the distribution of the forms studied that he has taken refuge in the idea of a great land mass that has long since vanished. To explain the distribution of certain organisms in Australia, New Zealand, South Africa and the southern end of South America, many persons have believed they were once in contact and have since drifted apart, or were connected by a land bridge or continent that has since disappeared. Particularly puzzled by the distribution of various forms in the Indo-Pacific realm, various workers have invoked the aid of a lost or sunken land mass over a a large part of what is now Polynesia. All sorts of organisms have been utilized in an attempt to show that their distribution has been due to some great land mass in the tropical Pacific, some continent or island of incredible vastness, which eventually disappeared beneath the sea.

If an animal is found in widely separated and unconnected localities, or closely related animals occur in such regions, we may assume that such places have been connected at some period more or less remote. That is to say, we may make such assumptions provided the organisms concerned can not fly or be borne about by the wind, are not carried about by man or other animals or attached to or within plants, and can not live in the sea for more than a very short time. Then before such assumptions receive credence they must be corroborated by geological evidence and further supported by additional data concerning other organisms, either plant or animal, or both.

Among the best organisms for the determination of former land connections are the fresh-water fishes. However, the term "fresh-water fish" must be applied with discretion. Not all fishes found in fresh water are entitled to be called true fresh-water fishes. This is conspicuously the case in some parts of the world.

Every one naturally and readily separates the fishes of Europe, northern Asia

and North America into two great groups. The one included all those that are marine, the other those that spend their lives in fresh water. While it is true that a number of well-known fishes are on the border line, or spend a part of their lives in the sea and a part in fresh water, there is never any real confusion in distinguishing one from the other. With the exception of salmon, some trout, alewives, fresh-water eels, and a very few others, the fishes of the regions cited spend their lives in either fresh or salt water. They may venture from one side or the other into brackish water and take up permanent residence there, or they may live in either fresh or salt water or in brackish water, but a very few venture into all three or live indifferently in all.

The case is very different when one enters the tropics. There the student of fishes is confused to find marine fishes living freely in fresh-water lakes and rivers, while in some regions the entire fresh-water fish fauna is really composed of marine fishes. This is true of the American tropics to a certain degree, but is characteristic of a large part of the Indo-Pacific realm.

This region contains very few families of fishes that are exclusively fresh water. The only ones of real importance are the Cyprinidae, the Ophicephalidae, the Anabantidae, several families of catfishes and the Mastacembelidae. Other families of true fresh-water fishes contain few species of small importance, except in Africa and South America. There the Characinidae, the Cichlidae and the Cyprinodontidae are very numerous and important. In the American tropics there are no cyprinids, their place being taken by characins.

In the rivers and lakes of the eastern and southern coast lands of Asia dwell an immense number of Cyprinidae, in a bewildering variety of species. Many kinds of catfishes, belonging to at least eight families, also inhabit these same waters. The other families mentioned are far more limited in their number and their variety of species. Of them all, the cyprinids are perhaps best suited to demonstrate the principles of zoogeography.

The great islands lying off the southeast of Asia also swarm with cyprinids, while catfishes, labyrinth fishes and mastacembelids likewise thrive in their waters. The geological evidence and the presence of identical species of cyprinids, labyrinth fishes and catfishes on the mainland of Asia and in Sumatra, Java, Borneo, Palawan, Mindanao and smaller islands along their coasts are sufficient to prove that these islands were once all connected and formed a part of the mainland. Together they formed the Sunda Land of Mollengraf. In addition, there is plenty of other evidence, botanical and zoological, to demonstrate the extent and validity of Sunda Land.

In addition to the true fresh-water fishes mentioned, many other kinds of fishes occur in the fresh-water streams and lakes of eastern and southern Asia and the great islands mentioned. One encounters sharks, snappers, mullets, sea-bass, Carangidae or crevalle, threadfins, Chanidae, tarpon, marine eels and Scatophagidae, just to mention a few, in strictly fresh-water rivers and lakes. They are found not only in the lower courses of rivers and in lakes near the sea, but often occur hundreds of kilometers from the sea. Some kinds seem to make but a brief excursion into some river and lake, while others remain a season or longer, up to several years, until they reach maturity and are almost ready to spawn before they start back to the sea. Often the number of a given species living in a certain lake or river may be very large, and give rise to important fisheries, but it is really only a small part of the total population of the species, the vast majority remaining in the sea.

None of the true fresh-water fishes

has succeeded in passing from Borneo to Celebes across the narrow but deep Strait of Makassar. One small cyprinid has passed from Bali to Lombok, but none of the other true fresh-water fishes has gone east of Wallace's line, which runs along the deep but very narrow strait east of Bali and continues northward through the Strait of Makassar.

On Celebes, Amboyna, Halmahera and perhaps others two true fresh-water fishes are found, but it is well known that they have been taken there by man. They are both labyrinth fishes, the climbing perch, *Anabas testudineus,* and a snakehead or murrel, *Ophicephalus striatus.* Both species have been very widely distributed by wandering Malay fishermen, and their presence in the East in the waters of an island is no proof of their being native there.

When one passes east of Wallace's line and enters the rest of the East Indies and the Philippines east of Palawan (which is included with Wallace's line), and passes eastward into the Pacific, a different world is entered so far as true fresh-water fishes are concerned. The streams and lakes are abundantly supplied with fishes, and a fair proportion spend all or most of their life in fresh water. There is an even greater variety of marine fishes in the fresh waters of this part of the tropical Pacific, while the apparently strictly fresh-water fishes are all members of families that are for the most part inhabitants of the sea. They are therefore recent migrants into fresh water which they found unoccupied by other fishes.

Characteristic of the streams and the lakes of Luzon are its fresh-water gobies, which occur in a bewildering variety. Most of them go down to the sea to spawn, though some, especially those found only in lakes and in mountain brooks, spend their whole existence in fresh water. To a lesser degree the same is true as one goes eastward and southward throughout the tropical Pacific. Those gobies which now remain permanently in fresh water, like the minute ones in the lakes of Luzon, are immigrants from salt water in recent geologic time.

Certain pipe-fishes and half beaks are also found very widely distributed in the fresh waters of the Indo-Pacific region. At least two species of Kuhlia, bass-like fishes of moderate size, are likewise in streams everywhere in the region. All these are marine fishes recently adapted to life in fresh water, and are able to survive long journeys in salt water. In some cases the fry, in others the adults are able to live in salt water for considerable periods. Therefore these and other fishes of recent migration to fresh water occur in suitable localities in the Pacific, even to the far-off Marquesas.

It is accordingly unnecessary to assume a lost continent, or to imagine great land masses covering parts of Polynesia and Micronesia, to explain the distribution of the fishes occurring in the fresh waters of the region east of Wallace's line. Any one who has fished by electric light at night in the East Indies or some Polynesian archipelago knows that a surprising number and variety of the fishes living in fresh water are dipped up as they float by in the tidal currents.

Once it was assumed that New Zealand, Australia, South Africa and the southern end of South America were all connected at some past era. This was because fishes of the genus Galaxias occur in the fresh-water rivers of all those regions. Later it was shown that Galaxias is able to live in salt water, and has migrated from the sea to fresh water in recent geologic time. The hypothesis of a land bridge to account for the distribution of this fish therefore vanished.

In the fresh waters of Australia, New Guinea, and some of the small islands

about and between them, and in Celebes, occur certain genera of fresh-water fishes which belong to the family *Atherinidae*. This family is largely composed of small temperate and tropical sea fishes, which have become adapted to living permanently in the sea. One group, probably developed in Australia, became distributed when New Guinea was a part of Lemuria, the land mass which included both Australia and New Guinea. Two other genera are found only in Celebes, which has evidently been cut off from other land areas for a very long time, so that all its fresh-water fishes are recent migrants from the sea, as is likewise the case in New Guinea.

As far as the evidence from fresh-water fishes applies, we may dismiss all idea of a lost continent in Micronesia or Polynesia. Wallace's line marks the eastern limits of the fresh-water fishes of Asia.

GALILEO AND THE MODERN WORLD

By RUFUS SUTER
LIBRARY OF CONGRESS

I

Galileo Galilei, whom most of us remember as the Italian who dropped balls from the top of the Leaning Tower of Pisa, was the first man in modern history to picture the universe as a machine. Proceeding from this new point of view, he discovered many laws of nature—among them the principle of the pendulum, the laws of bodies in equilibrium and of bodies falling, whether dropping freely, rolling down inclined planes, or flying through the air as projectiles. And he established also a few principles concerning the action of lodestones.

Once Galileo had shown the way, people who were curious about nature continued to think and proceed according to the pattern he had outlined. With his example of the kind of knowledge to seek, they discovered the rules or regularities involved in the conduct of gases under pressure, of light and heat, of sound, of chemical combination, of steam, of magnetism and electricity. The process of discovery has been advancing now for more than three centuries and its possibilities are not exhausted. In the meantime, civilization in Europe and America has been transformed from its roots to its highest branches, and the older cultures of Asia are following.

This Italian scientist, in other words, by teaching us a fecund conception of natural law and a fruitful method of interrogating nature, became one of the most influential among the thinkers and men of action who have given us the modern world. We may meaningfully ask: If he had not lived would we to-day have our giant bridges and skyscrapers, our railroad trains and radios? His importance is such that we should be as well informed about him as we are about the most intrepid explorers and acutest scientists of to-day.

Galileo was an inventor. Contrary to popular opinion, however, the only instruments of which he was literally the originator were the pulsilogia and the sector. The former, based upon his discovery that the pendulum is a regulatable and dependable timekeeper, was a machine for measuring the pulse beat. It proved to be more of a curiosity than a fruitful suggestion to medicine, but it was the forerunner of the pendulum clock, a drawing of which was the last device he diagrammed before his death. His other original invention, the sector

(or military and geometrical compass), was a mathematical instrument of use to architects and surveyors and, financially, was the most successful of his instruments.

The devices popularly attributed to Galileo: the telescope, microscope, air-thermometer, the hydrostatic balance (for determining the specific gravity of bodies) and the armature (for increasing the power of magnets) were not actual inventions, but in each case marked a vast improvement over anything which had preceded them. His strongest telescope, for example, magnified about thirty diameters, whereas the original telescope, made in the Netherlands, was a mere plaything.

Another of Galileo's inventions—a method rather than an instrument—was a means for determining longitude at sea. Although for centuries navigators had been able to compute latitude (it was simply a matter of taking the difference between the altitude of the Pole Star and 90°), the problem of longitude was much more difficult. Several European governments, appreciating the practical importance of a solution to this riddle, offered prizes for suggestions. Galileo proposed to enlist in the service of navigation the four moons of Jupiter which he had discovered. His idea was this: If ephemerides of the Jovian satellites were drawn up for Florence—a task to which he devoted many years—an eclipse, for instance, of one of these bodies as seen from Florence could be predicted to the hour and minute. Then out at sea, in a different longitude, the navigator would only need to figure the difference between the time at which he had observed the eclipse and that predicted by the Florentine tables in order to have a basis for determining his longitude. The longitude of Florence could be taken as zero. Since the earth turns at the rate of fifteen degrees per hour, the difference between the two times multiplied by fifteen would give the longitude of the ship. This method was theoretically possible, but practical difficulties rendered it useless. In the first place there were not yet clocks that would keep the time from one noon to the following evening with sufficient accuracy. In the second place, it was impossible to make precise observations of Jupiter's moons from the rolling deck of a ship. Galileo had ideas for overcoming both these difficulties: he proposed the use of the pendulum as a timekeeper, and he devised a telescope which could be worn by means of a frame on an observer's head and shoulders while the observer sat in a chair floating in a tub of water on the ship's deck. But the time was not yet ripe for the solution of the problem of longitude. Of all the governments with which he negotiated, only the Tuscan gave his scheme a trial, and that to no avail. The kernel of his idea, nevertheless, was suggestive. Not Florence but Greenwich afterwards became the baseline for longitude; not a pendulum clock but the ship's chronometer was developed; ephemerides not for the Jovian satellites but for the sun, moon, planets and stars were published for the use of navigators by most of the important maritime powers of Europe.

All in all, if Galileo had been an inventor only he would have been as outstanding a figure in history as Edison. But as fortune had it he was more than an inventor. The evolution of any mechanical device from the primitive stage to that of most usefulness requires a special climate. The latter is indispensable, for without it, an invention—no matter how promising—is bound to die sterile. Galileo was remarkable in that he combined in himself both practical, inventive, technical genius and profound insight into abstract science. Thus he was able not only to plant many

seeds, but also to aid in developing a climate of abstract thought highly conducive to their growth.

II

If we remember Galileo as the Italian who dropped balls from the top of the Leaning Tower of Pisa, we may also recall him as the man who irritated the Roman Inquisition by holding that the earth spins on an axis and swings around the sun. We can not grasp the significance of his contribution to abstract thought until we have understood the church's as well as his side in this famous dispute. The issue cut far deeper than any mere question of whether the earth moves.

We should remember that for a thousand years Europe had grown up under the guide strings of Catholicism. Under her tutelage the Teutonic barbarians from the north, who had been instrumental in breaking up the ancient Roman Empire, had been civilized and a political and intellectual unity of Europe had come into being which has never since been paralleled. There had evolved a marvelously stable social and economic structure and a code of law and morals which every responsible person regarded as God-given. This structure and code people believed were intimately connected with the picture of the universe in the Old Testament and in the Christianized version of the Greek philosophers, Plato and Aristotle. In those books was the whole truth. Whoever doubted them was undermining the nethermost foundations of society. An innovator was seen in the same light as we to-day would regard a communist and atheist.

If we wish to characterize in a word the picture of the world which our medieval ancestors and which most of Galileo's contemporaries held sacrosanct, the least we may say is that for them the universe was a moral and legal order.

It will also help us to understand the antagonism between the ecclesiastical authorities and Galileo if we recall that the century in which he lived was witnessing the death struggle of purely Catholic conceptions as dominating the European scene. To the Pope and cardinals who condemned Galileo the pillars of civilization must have seemed to be collapsing. Protestantism in religious affairs and nationalism in politics (both denials of the ideal which Rome had spent a millennium in upbuilding) were gaining ground. The Moslem Turks were making trouble in Austria and Hungary. The Thirty Years' War was raging. Old cultures, thoroughly developed but strangers to the influence of Christianity, were being discovered. People were sailing to lands 10,000 miles away: the Americas, India, China, Japan, Australia. Then in the midst of this turmoil Galileo arose and from another angle threatened to knock the bottom out of the painfully won thought-structure of conservative men. The Pope and cardinals deserve admiration for having appreciated that the apparently remote, academic cogitations of an abstract scientist could play a devastating rôle in the chaotic world of practical affairs.

What was the revolution which Galileo championed? He was perhaps the most effective personality in the small group of men who in the sixteenth and seventeenth centuries began to re-think the basic features of the universe so that physical science could evolve. By "physical science" we mean science as we know it now: a deliberately planned, organized, systematic body of knowledge about physical things capable of providing us with the means of making predictions and thus of controling nature on a vast, cooperative scale. Galileo, in other words, ignored the traditional and respectable view that the laws governing the universe are literally *laws*—judicial

and moral statutes and rules asserting a fitness and usefulness in things. Instead, he was the first among modern men to begin to think in terms of an un-judicial, non-moral, de-humanized kind of law. He switched from the vision of the world as the unrolling of a legal mind to that of the universe as an intricate system of cogs, pulleys, levers, tops, balls rolling down inclined planes, pendulums, magnets and shifting geometrical figures.

The object of the student of nature, as Galileo began to conceive it, was the same as that of the tester of a machine: to approach it, in the first place, knowing full well that it is a machine, and hence to be able to anticipate, to a degree, the kind of conduct in process; then to watch the machine run, with a clock, compasses and gauges, a ruler, a magnifying glass, etc., at the fingers' tips. The information to be obtained was accurate measures of size, speed, direction of motion, weight, number and arrangement of parts.

Galileo's conception of method may seem self-evident to us. We may find it difficult to grasp the length of the leap which he took. But after his time the student of nature was no longer a scholar comparing texts of Aristotle, no longer a mystic trying to decipher the attributes of God as symbolized in natural phenomena, no longer even a simple man of common sense seeking to understand *why* or *for what purpose* water flows down hill, earthquakes occur and grass is green. The student of nature became a technician, asking and answering only one question: "*How* does this or that contrivance in nature work?" and the aim was to frame a reply in mathematical notation.

Galileo's inventions were important. His discoveries with the aid of his telescopes were important. One always remembers with a shock that he was the first human being to know that the moon is a world with mountains and plains, that Venus has phases, that the sun has spots and rotates, that Jupiter has moons, that the Milky Way is a throng of stars. But immeasurably more significant for later history than any of his inventions or discoveries were his picture of nature as a machine and his conception of scientific method as a super-refined empirical examining of the parts of the machine to unravel regularities in its operations—regularities which one knows in advance to exist, because such is the nature of a machine, but which one does not know specifically. From this point of view has come the body of physical science, theoretical and applied. From this body has sprung our modern industrial civilization.

SOME ECONOMIC REPERCUSSIONS OF MEDICAL PROGRESS

By Dr. WILLIAM B. MUNRO
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I

The habit of over-simplification is probably the most wide-spread of our present-day intellectual depravities. With their heads as well as with their hands people are trying to get results with the least exertion. One need only listen to popular discussion on any nation-wide problem to see with what marvelous ease the practical difficulties are brushed away. Situations which have evolved from the interaction of many complex forces are relegated to a single cause in this process of wishful thinking. Thus we find the economic vicissitudes of the modern world attributed to mass production, the machine age, the profit system, the burden of taxes, the breakdown of international commerce or to some other simple origin which can be compressed into a single phrase. It betokens the impatience of the public mind with any and all explanations that can not be reduced to a formula.

Yet it ought to be self-evident that a great many forces and factors have combined to throw the world of to-day off its normal economic balance. No one of them could possibly have done it. The interplay of several has been required to do the job. Nor are our contemporary troubles the outcome of forces which began to operate during the past few years, or even a whole generation ago. Some of them have been gaining momentum for over a century, ever since the days of the industrial revolution. Others began to operate much later but have gained strength so rapidly as to make up for a belated start. Long ago it ought to have been realized that these developments were destined to compel great changes in our economic life and organization, but for the most part, the omens were ignored. Now the world is hurriedly trying to figure out what happened to it.

One thing, at least, of far-reaching importance has happened to it during the past hundred years or thereabouts. The population of this planet has doubled during that time. There are about a billion more people on the earth to-day than there were in 1840. Malthus would have flatly declared that no such increase could possibly take place in a hundred years or even in several hundred years. The pressure on subsistence would have stalled further increase, according to the Malthusian law, long before the doubling point could be reached. Yet it has been reached, and if the rate of growth is now slackening somewhat, it is not because there is too little food to go around. In America there is too much. That is one of our troubles. If you doubt it, ask any farmer.

Where Malthus erred was in assuming that, so far as his capacity for economic production goes, man is a machine of relatively fixed output. Advances both in technology and in medical science have shattered that assumption. The growth of population has been outstripped by increased efficiency. But when we talk about the Machine Age, let us not overlook what has happened to the *human machine* through its increased life expectancy, greater freedom

from illness, more rapid recoveries from injuries and improved physical vigor all along the line. Comparative figures of population do not tell the whole story. World population has doubled in a century, but in its ability per capita to utilize the resources of the earth it has done a great deal more than that.

The productive capacity of the two billion human beings who inhabit the globe at the present time is several times that of the one billion who dwelt upon it at the beginning of the Victorian era. This, of course, is primarily due to the way in which machinery has been brought to the aid of man. Steam and steel have taken over tasks that strained the muscles of millions. But in considerable measure our enormously increased economic productivity results from the fact that man, on the average, is himself a far more efficient mechanism than he was a century ago. Inventors and engineers have done their share; but the service rendered by medical science to the augmentation of human efficiency is something that should not be overlooked in any discussion of such economic problems as overproduction and unemployment.

Even a hundred years ago, a large portion of the earth's surface was unable to produce anything beyond the needs of its own inhabitants. These areas had as much in the way of natural resources as they possess to-day, but their possibilities remained undeveloped because the white man's leadership was lacking. Plagues and pestilences, such as malaria, yellow fever, typhus and sleeping sickness, made it virtually impossible for white men to live for any length of time in tropical and semi-tropical regions throughout most of the world. But during the past half century the progress of medical science has established human mastery over these scourges, and vast tropical areas have been enabled to increase their productivity many times over. One can realize on a moment's reflection, for example, what the conquest of malaria and yellow fever has meant to the production of sugar in Cuba, fruits in Central America and coffee in Brazil. It is not new methods of agriculture but progress in disease eradication that has brought Egypt and the Soudan into the world's cotton market and made the west coast of Africa a great producer of crude rubber. There is hardly a great staple of trade which has not had its world supply increased during the past fifty years by the opening up of regions which could not be exploited earlier because of their inroads upon the lives and health of the people. All this, quite naturally, has had its repercussions in fields of diplomacy and international competition. What used to be known as the waste places of the earth are now coveted by nations which regard themselves as overpopulated or lacking in natural resources.

We speak of the Panama Canal as a great triumph of engineering skill. What it has meant to the development of seaborne commerce between the two coasts of America and between Europe and the Orient is something that needs no elaboration here. But no amount of engineering skill would have availed to build that waterway had it not been for the marvelous advances in tropical medicine which preceded the work. It was not the invention of the steam shovel but the conquest of malaria and yellow fever that made it possible for Goethals to succeed where his French predecessors had failed.

II

Of all the plagues that have afflicted the world in the course of human history, it is probable that malaria has taken the largest toll. Not that it has been so virulent and periodically devastating as

some others, such as bubonic, but its incidence has covered the tropics, the semitropics and even the southern portion of the temperate zones. No other disease has been so persistent for at least twenty-five hundred years. The Athenian empire counted malaria its worst and most implacable enemy. If Athens could have conquered malaria she would have ruled the world. Rome, too, was scourged by malaria throughout her history. It carried off more of her soldiers than were slain in all the wars that Rome waged with her neighbors. Situated in a low, marshy area, the City of the Seven Hills was hounded by "fever" as regularly as every summer came, and the eventual emaciation of the people in this imperial capital must be reckoned as one of the causes of its collapse.

The Roman authorities put forth great efforts to discover the cause of malaria and, as a matter of fact, came nearer to success than they realized, for they became convinced that it was a "pestilence that walketh by night." It was a disease borne by the night air. Hence the best way of avoiding the infection was to close the windows and doors of every house tightly from sundown to sunrise. Correct procedure this was, so far as it went, but no Roman had ingenuity enough to take the next step by suggesting a possible relation between night air and mosquitoes. Not for fifteen hundred years after the fall of Rome did the world place its finger upon the *Anopheles* as the real source of the trouble.

It is true that the mosquito had been under suspicion for a long time, but guilt could not be definitely fixed upon his tribe as a whole. Long and patient experimentation was required to find out that among the hundred or more species of mosquito, only a very few ever carry infection from one human being to another, and that even among these it is the female alone which can carry it. The process of infective transmission, moreover, requires a certain interval of time, and the problem of determining this was one that long baffled the investigators. Even after the route of infection became definitely established, there was considerable difficulty in convincing the public authorities and the people of tropical areas that malaria and yellow fever could be brought under control by eliminating mosquitoes at their source, more particularly by the use of oil on the surface of stagnant waters. When the Rockefeller Foundation, for example, undertook to help this work of mosquito eradication, there were millions of people quite ready to believe that the whole thing was merely a scheme to enlarge the market for Standard Oil.

Bubonic was for many centuries the most spectacular of the great plagues. The probability, is, however, that estimates of bubonic mortality have been exaggerated. The Black Death of 1348–1351 is said to have carried off from a third to a half of the English population. And it is true that in some of the English monasteries, where records were carefully kept, the mortality did reach that proportion. But the ratio of deaths among residents of the monastic establishments would naturally be larger than that among the people as a whole. The monks had the duty of visiting the sick and administering the last rites of the Church to the dying. They were exposed to direct infection in doing so. And since they lived together in the monastery the opportunities for spreading the plague among themselves were abundant. In the rural areas where the people were scattered and had little contact with the towns there was a far better chance of escaping the ravages of bubonic, and it is altogether probable that the death rate in such communities was much lower.

Nevertheless, the successive waves of bubonic which swept over Europe during the long stretch between the twelfth and the eighteenth centuries were not only decimating in their effect on human life, but they left large numbers of people weak and enfeebled. Unlike malaria, which took its largest toll from the countryside, bubonic wrought its principal devastation in the cities, especially in the port cities to which the sailing vessels brought their supply of flea-infested rodents from Asia. Down to the close of the seventeenth century it is improbable that any European city had a death rate below its birth rate, even though birth rates were high. When cities grew, it was wholly because of migration from the rural districts.

So it was the progress of medical and sanitary science that made large cities possible. If the major routes of infection in the case of such diseases as malaria, bubonic, smallpox, typhoid and dysentery had not been found, there could have been no such amazing urban concentration as the world has seen during the past hundred years. That is another way of saying that there could have been no development of great industrial establishments, for the big industries are virtually all of them in or near the great cities. This, of course, is not an accident. It is something that had to be. Industrial production seeks economies by enlarging its scale. Its influence on population becomes centripetal because the thousands of workers in giant industries must live within a reasonable radius of their work. The automobile has helped to widen this radius, but even so the worker dislikes to live more than a half-hour from his labor. It becomes essential to the progress of industry, therefore, that great centers of population shall be reasonably safe against those inroads on health which would ordinarily result from congestion. Medical science has made them more than reasonably safe. It has made them safer against water-borne and insect-borne diseases than are the rural areas.

The conquest of typhoid, for example, is one of the spectacular achievements of the past generation. Fifty years ago no large American city was ever free from this disease. Epidemics of it were of such common occurrence that people regarded them with the same nonchalance that they now look upon traffic fatalities. But to-day there are large cities which go through the year without a single case of typhoid. When Sir William Osler published the first edition of his "Practice of Medicine," he devoted more space to typhoid than to any other acute disease. Now it has become one of the rarer afflictions, so much so that general practitioners often do not encounter a single case of it in years.

During the Spanish War (1898) a division of about 12,000 American troops was encamped for a few months at Jacksonville, Florida. More than three thousand cases of typhoid developed at that camp. But during the World War (1917–1918) a division of troops numbering more than 25,000 men was trained for a longer time at the same place, and not a single case of typhoid occurred. That is a striking example of what medical progress was able to accomplish in twenty years. Protection of water supplies and anti-typhoid inoculation combined to eliminate what had been for many generations one of the epidemics of every military encampment.

III

Then there is the progress that has been made in the field of surgery. Industry in all civilized lands has gained enormously by the better treatment of injuries resulting from industrial accidents at the time they occur. Few people realize how much time was lost to the

worker in earlier days by reason of accidental injuries. Accidents were numerous, and their frequency was not wholly due to the lack of mechanical safeguards. Many of them were the result of defective eyesight, which went uncorrected. The science of optometry was still in its primitive stages; defects in the vision of industrial workers were badly diagnosed and even more crudely remedied.

Injuries which involved even minor amputations had a fatal outcome in a large percentage of cases. Lord Lister, although he was perhaps the most eminent of nineteenth-century English surgeons, had an operative mortality of about 45 per cent. after amputations during the earlier part of his professional career. And industrial accidents which did not involve amputations usually resulted in prolonged lay-offs because the injuries could not be induced to heal. It was not until the last quarter of the nineteenth century that the antiseptic, and later the aseptic, treatment of injuries became general. Even then the technique left much to be desired. There are those still living who can remember the time when minor cuts and abrasions led almost inevitably to suppurations which incapacitated workers for weeks at a time. To-day the amount of time lost by either agricultural or industrial workers as the result of injuries is relatively small. Their productive capacity has been proportionately increased.

The loss of workers' time because of minor illness has also been greatly reduced. To take only one example, the improvements in the preservation of food have cut down the prevalence of ptomaine poisoning, diarrhea and other intestinal upsets to a small fraction of what they used to be. Infected teeth and tonsils were prolific causes of impaired physical vigor fifty years ago but were rarely recognized as such. More often than not, moreover, the onset of a communicable disease escaped detection until after fellow workers had been directly exposed to the contagion. Men and women with tuberculosis struggled along with their work, coughing and expectorating, quite unmindful of the danger to others. It would not be an overstatement to say that the physical capacity of the average industrial worker in the United States has been at least doubled during the past half century as the result of improvements in medical and surgical science.

Progress in medical science has also had far-reaching repercussions upon the development of agriculture. The vast extent of the dairying industry is largely due to it. Most people do not realize that only during the past hundred years has milk become a prime staple of human consumption. If there had been any such general use of milk in human diet before the days of Pasteur as there is to-day the ravages of fluid-borne disease would have swept the cities everywhere, for milk is potentially the most dangerous of all the commodities which people consume. No other article of nutrition is so easily contaminated, and in the case of no other article are the results of pollution likely to be so serious. For when pathogenic bacilli get into milk, they find a culture in which, under favorable conditions of temperature, they multiply with extreme rapidity. Then they go directly into the nourishment of those who have the least individual resistance to infection, the children and invalids of the community. Nevertheless, from being potentially the most dangerous of foods, milk has now become one of the safest. This safety, which is the result of progress in bacteriological science, has built up a billion-dollar industry in the United States.

On the other hand, the wheat farmer has not fared so happily as the result of what medical authorities regard as an advance in the science of dietetics. Even

a generation ago bread was regarded as the staff of life. In every American home it came on the table three times a day. And among staples of family diet the potato ran it a close second. But with large elements of the population both these foods are now in eclipse. Both are losing ground. The per capita consumption of bread in the United States is to-day smaller than it was at the beginning of the twentieth century. It is not because bread is more expensive or less palatable now than at that time, but largely because of the conviction that eating bread disposes to overweight, and with the feminine half of the population, this alone is enough to render it taboo. The American wheat farmer is having his troubles, and they are not wholly due to the shrinkage in his foreign market. Accepted ideas concerning the relation between diet and a slim figure have had much to do with it. So serious to the baking companies has the situation become, at any rate, that they have launched a great advertising campaign to reestablish bread and allied products in the public favor.

Where cereals have lost ground, fruits and green vegetables have gained. Dietary advice from the medical profession has substantially affected the consumption of other foodstuffs and to that extent has deflected the normal course of agricultural production. But there is one field in which the American people pay little or no attention to medical advice, or, indeed, to advice from any quarter. The consumption of beer is declining while that of spirituous liquors is increasing year by year. Whether the substitution of canapés and cocktails for bread and beer will augment the physical vigor of the race is open to something more than doubt.

IV

Perhaps the greatest progress that medical science has made during the past century is in the reduction of infant mortality. The death rate among babies to-day is not a quarter of what it was a century ago. Birth rates have also been declining, it is true, but not fast enough to offset the gain. The increase in world population has been more largely due to this factor than to any other. Life expectancy, when reckoned at birth, has therefore been greatly lengthened. When reckoned at subsequent stages along the journey it has also been lengthened, although, of course, not so greatly. The result has been to draw a larger percentage of the population into the upper decades of age distribution. Or, to put it more baldly, the progress of medical science has had a good deal to do with the growing seriousness of our old-age pension problem. It has enabled a steadily greater proportion of the people to prolong their lives beyond the age of sixty or thereabouts, that is, beyond the point where they can compete in productive capacity with younger workers.

This large and steadily increasing group, finding itself crowded out of gainful employment by the competition of younger men and women, now insists that it shall be supported by the contributions of those who have done the crowding out. It is not an unreasonable demand by any means, although one may venture to add that the problem of devising a practicable way of meeting it will not be solved by adopting any of the crackpot schemes which are now being promoted without regard to their general economic implications.

This problem remains one of the most urgent and perplexing dilemmas of our time. Plagues, infections, famines, wars and ignorance of bodily hygiene took care of it in days gone by. Wars are still with us, but despite the infinitely greater destructive power of military weapons it is a fact that warfare is not relatively so destructive of human life as it was in

earlier years. This is because the losses from disease and from the fatal termination of wounds have been enormously reduced. Famines no longer take such toll among the aged as they used to do. For in civilized countries they do not occur on any large scale, and when they do happen there are relief organizations to take care of them. Ireland could have been fed during the potato famine of 1848 as easily as Belgium was succored by America before we entered the war. The difference prefigures one of the humanitarian advances which civilization was able to make during the intervening seventy years.

There is no reason to suppose that medical progress has reached its limit. On the contrary, there is every reason to expect that it will keep on devising means whereby more and more people will find themselves projected into the sixty-to-eighty age group. If we adopt the principle that all these must be supported from the earnings of workers who are in their junior decades, we should give some heed to the size of the burden which this will ultimately involve. Calculations based upon the age distribution of to-day are almost certain to prove wide of the mark. Any sound plan for old-age pensions must envisage a steady increase in the number of those eligible to receive its benefits. Hence, if the load is not to become unbearable there must be a corresponding increase in the productive capacity of those who have to carry it. So the crux of the whole problem is not who should receive pensions, or when, or how much. It is this: How can we increase the national income to a point where this large and steadily mounting cost can be borne without lowering the standard of living among those who have to pay it? In current discussion that phase of the problem has been getting far less attention than it deserves.

YOUTH, AGE AND CITIZENSHIP

NOBODY wants to set youth against old age. But the old people who have organized for their own economic interests are so much more skilful and experienced in political organization that they have a great advantage over young people. There are thirteen million people over the age of sixty in this country. They have the vote, they have plenty of time for political activity, and they know how to make political activity count. Furthermore, they can look for aid to another thirteen million people between the ages of fifty and sixty, who are already facing old age. It is not easy for these folk who have passed the peak of life to realize that twenty-four million young people between the ages of fifteen and twenty-four are climbing the hill on the other side against obstacles more baffling than anything which the older generation went through.

. . . One feels that much of current educational change is merely tinkering with machinery that has grown obsolete. One looks in vain for the radical changes that would seem to be called for when secondary education takes on new functions to serve new types of students.

Too many people seem to be victims of an unjustified faith that if boys and girls are kept during their 'teens in the red brick isolation of a school building, they will emerge on graduation day as full-fledged men and women ready for adult life in a complex and changing society. One suspects that young people must spend less rather than more time in school buildings, that schooling and useful work must go together, that young people must live more and work more with their elders in their community, if the goals of modern secondary education are to be reached.

Will the educational profession provide the imagination and leadership necessary to meet the situation? Will the lay public accept this leadership and support the radical educational changes that may be proposed?—*Robert J. Havighurst, in the Report on the Program in General Education of the General Education Board.*

BOOKS ON SCIENCE FOR LAYMEN

THE COSTS OF MEDICAL CARE[1]

HUGH CABOT has written a first-class book, but it might well be titled "The Doctor's Dilemma" instead of "The Patient's Dilemma," for fundamentally it has to do with the relationship of the physician to the problem of providing adequate medical care to all elements of the population of the United States. The book brings out the difficulties that have been encountered by the medical profession in facing certain social trends and certain inevitable changes that have come about with the advancing social patterns of American life.

While the doctor has been confused as to just how he should play his part, the intelligent citizen has been trying to find out just what should be done in order to see that he and his family receive modern medical care at a cost that could be brought within the family budget. When it is so difficult to bring about change in a wise and satisfactory manner it is natural enough for opposition to arise among those who must change with change.

Dr. Cabot shows that while great gains have been made in modern medicine the costs of medical care have steadily increased. There is no good way to provide a cheap form of medicine for one person with appendicitis and a costly form for another. Scientific knowledge has brought such basic changes in the standards of medical education and medical care that good medical care for any one or every one is requiring expanding expenditures.

In his early chapters Dr. Cabot makes the point over and over again that the findings of science are responsible for these fundamental changes and for the new methods required in medical practice. The analysis which follows of the various experiments that have been undertaken in spreading costs among large groups of individuals or even giving national spread to them is informative and is necessary for an understanding of practical suggestions for an American program of medical care.

As a physician the author of this book understands the predicament in which physicians, nurses, hospitals and others find themselves in relation to the problems of costs, and is aware of the various obstacles that have been set up by physicians, as organized in state and national societies, largely through fear of change and a consciousness of the vital importance to satisfactory medical care of a personal relationship between the doctor and patient.

There has been an impression among certain sections of the public that if the government stepped into the picture and provided funds the problems of medical care would rapidly disappear. Dr. Cabot is wise enough to realize that the mere provision of funds will not solve the problems of good medical care and may even intensify them. There are, though, certain factors involved and these include the resources of the government as well as all other forms of social organization in which medicine is involved.

The author explains that new patterns and new techniques are needed to meet this country's problem of extending the application of the benefits of the health sciences; that effective action depends upon some combination of resources from *Government*—federal, state and local, from the *Public*—as patients, and from the *Medical Profession*—as the technicians; that leadership can but come from the profession, aided by experts in economics and government; that promo-

[1] ***The Patient's Dilemma.*** By Hugh Cabot, x + 284 pp. $2.50. Reynal and Hitchcock, Inc.

tion of scientific study, high standards of education, opportunities for efficient work will have to be safeguarded, as schemes are designed for equitable financing and sound administration.

Dr. Cabot does not under-estimate the difficulties; he does not over-estimate immediate results nor forecast Utopia; he does believe that, with the spread of knowledge of the benefits to be gained from medical science, public demand for these benefits rightfully increases; he does believe that efforts to anticipate and meet this demand are important to our democracy; and he does believe this accomplishment is possible through democratic processes.

When he says: "I am giving voice to 'the faith that is in me,' " Dr. Cabot expresses reliance upon a philosophy of action in dealing with public matters which is rooted in idealism similar to that which guides most physicians in matters of service to the sick. It is the sort of thinking that can find the way over, around and through the obstacles which stand in the way of spreading the benefits of medicine and which will help the profession and patients to go at common problems together.

The spirit of Dr. Cabot's book can best be understood by his last paragraph on "Long Distance Planning in Democracy":

> . . . we have an immense body of opinion, part of which is in this country, a handsome part of it elsewhere, which continues in spite of discouragements, to believe that there is in all human beings an inherent and irresistible desire for certain freedoms which can be obtained only under democracy. Such a view seems to me based upon irrefutable evidence going back to the beginnings of the world. Its validity I can not doubt. Once we admit this premise, once we admit that we believe that there are in democracy certain inherent benefits essential to progressive civilization, then we are driven to the conclusion that though long distance planning under democracy is beset with many vicissitudes, nevertheless such plans must be made and, by dint of good temper and the laws of the cosmos, they may come to fruition.

RAY LYMAN WILBUR, M.D.

PRESERVATION OF MENTAL HEALTH[1]

THERE exists in this country a large body of intelligent and thinking citizens who desire authoritative information on matters pertaining to health and its preservation. The wide interest in mental health is due in part to the fact that more beds are provided in mental hospitals than in all the other hospitals of the country put together, but in greater part to the close tangency of psychiatry to many fields of human activity, and to the fact that especially in times like those in which we now live nearly every one is aware of the need of a certain amount of effort in his attempts to preserve mental equilibrium.

As a means of "fulfilling its sole purpose, that of advancing the interests of science and society," the American Association for the Advancement of Science in December, 1938, presented a symposium on Mental Health, the 49 papers and 41 discussions of which form the present volume. Dr. Walter L. Treadway, then assistant surgeon general of the U. S. Public Health Service, drew up a systematic plan and secured the services of prominent authorities in the fields of psychiatry and such related topics as social work, statistics, anthropology, occupational therapy and psychology.

For obvious reasons, the substance of this volume can not be abstracted within the limits of a review; indeed, each article is compressed within such limits that it can be summarized only with difficulty. An idea of the scope may be conveyed by enumérating some of the subjects discussed: Orientation and

[1] *Mental Health.* Edited by Forest R. Moulton and Paul O. Komora. 470 pp. $3.50. 1939. The Science Press.

Methods in Psychiatric Research, including, for example, Research Problems in the Field of Clinical Psychiatry, Abnormal Behavior in Childhood, and The Function of Biometric Methodology; Sources of Mental Disease: Their Amelioration and Prevention (Genetics and Heredity, Alcoholism and Mental Disease, The Vitamins, Immigration and the Mental Health of Communities); Economic Aspects of Mental Health (Magnitude of the Problem, Economic Loss Due to Mental Disease, Family Care of the Mentally Ill, Social Security Measures as Factors in Mental Health Programs, Influence of Economic Factors); Physical and Cultural Environment in Relation to the Conservation of Mental Health (Community Differences and Mental Health, Selective Internal Migration, Segregated Communities and Mental Health, Political Psychiatry); Mental Health Administration (Purposes of a Centralized State Administrative Organization, A State Program for the Supervision and Training of the Feebleminded, Admission to Hospitals for Mental Disease, Psychiatric Expert Testimony, Psychiatry in the Community, Statistics in Relation to Mental Hospital Administration, Mental Health Administration as a Function of Government); Professional and Technical Education in Relation to Mental Health (Criteria of Specialists, Clinical Training of Psychologists, Status of Psychiatric Nursing, Training of Psychiatric Social Workers, Relation of Psychiatry to Internal Medicine). The volume concludes with a chapter by way of summary and prospects, entitled "Human Needs and Social Resources," by Dr. C. Macfie Campbell, of Boston.

The book is comprehensive, thorough and authoritative, and should be read by all who have a serious interest in social problems and in the preservation of mental health, with all which that implies for the welfare of the individual and the group.

WINIFRED OVERHOLSER, M.D.

A LONG PERSPECTIVE[1]

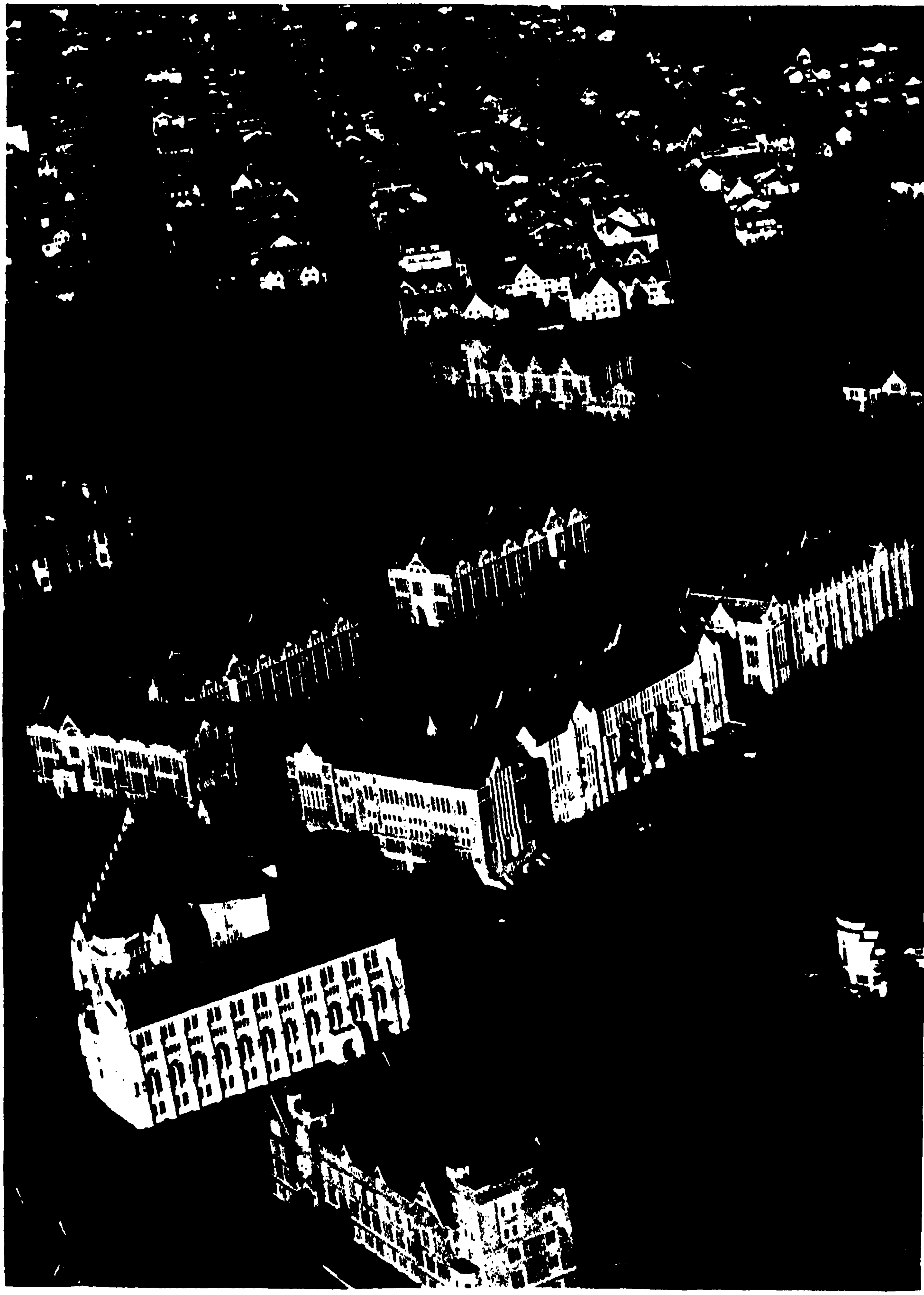
THIS new book by Childe, the author of many books and articles on archeology and the early history of man, is not simply a fascinating account of the rise of civilization. It describes with admirable clarity the accomplishments, the primitive scientific discoveries, that have marked the beginning of new epochs in human progress. For example, the author presents a very fine discussion of the importance of human speech both as a means of making available the experiences of one person for the information of others and also as an indispensable aid to generalizations and what is often termed "abstract thinking."

In a chapter on "Time Scales" the author gives a succinct and vivid outline of what is known of man down to the historic period. He warns his readers of the considerable uncertainties of the dates assigned to various prehistoric remains and of the dangers of assuming that primitive peoples of to-day are similar to prehistoric men.

In a final chapter following discussions of various "revolutions" in the culture of ancient civilizations in Asia, Egypt and Europe, Childe considers the question of the acceleration and retardation of progress. This chapter is a penetrating discussion of the deep-seated causes of the advances and the declines of civilization, a discussion doubtless stimulated in part by present world conditions and especially interesting because of them. The book is admirably adapted for the non-specialist in the history of the rise of ancient civilizations.

F. R. M.

[1] *Man Makes Himself.* By V. GORDON CHILDE. xii + 275 pp. $2.50. 1939. Oxford University Press.



AN AERIAL VIEW OF THE UNIVERSITY OF WASHINGTON CAMPUS

SHOWING THE LIBERAL ARTS QUADRANGLE IN CENTER, THE HENRY A. SUZZALLO LIBRARY IN LEFT CENTER AND PHYSICS HALL, HOME OF THE PHYSICS DEPARTMENT, IN CENTER FRONT.

THE PROGRESS OF SCIENCE

SCIENTISTS PONDER AT SEATTLE

About 1,100 scientists assembled in Seattle, Washington, from June 17 to June 22, to attend a joint meeting of the American Association for the Advancement of Science and its Pacific Division. During the five days of the meeting 644 addresses and papers were delivered or read. The subjects discussed ranged all the way from exterior galaxies of billions of stars to subatomic units of matter; from flights in the substratosphere to plumbing the depths of the ocean; from the restless mind of man to the half-live viruses. While one group was looking back down the long vistas of the geological ages another was considering phenomena lasting only a millionth of a second; while one was absorbed in the abstractions of mathematical analysis another was engaged in the immediately practical problem of growing food.

There was variety in the scientists as well as in their specialties. They came from 31 states, though largely from the Pacific Coast, and from Canada and the Philippines and Hawaii and England and France. There were American-born and European-born; there were veterans in science, and there were those who were just entering on its adventures.

It would be easy to write of interesting aspects of science that were discussed at the meeting of the association in Seattle, of the importance of the papers presented, of the enthusiasm of the participants, of the bright hopes for the future progress of science. However, all these things are characteristic of every meeting of the association, and at Seattle something entirely new was happening. World-shaking events were taking place in Europe. Those were the days in which the Allied armies were crumbling before the German attacks and when several million homeless refugees were pitiably struggling in misery to escape destruction. Every paper and radio report brought accounts of new horrors—death from the land, the sea, the air, to armies and civilians alike; the French pleading for an armistice; a government, if not a civilization, dying.

Naturally the minds of every one turned continually to these swift and tragic developments; the reactions to them were various, for scientists first of all are human beings. Though they condemned the German, the British and the French leaders, sometimes in strong terms, there was nevertheless a rare restraint in judgment, an exceptional degree of tolerance for those whom they censured. For example, there was no hysterical raving against Hitler or wishing that he might be assassinated or die a horrible death. The scientists showed that they are emotionally more mature than average men and women.

A much more interesting fact is that their training, their habit of looking for causes and taking the long view, led many of them to ponder the meaning of the present conditions. As scientists, they had gloried in the achievements of science—the superstitions and fears it has banished, the deep satisfactions in understanding the universe it has given, the food and comforts and improvements in health it has provided. How often they had boasted of these things and claimed that science promises the millennium! But wait! The engines of destruction laying waste Europe are also the inventions of science. The underlying causes of the current wars are due to the applications of science; the almost instantaneous dissemination of news of it is by means of the instruments of science. It is said, but with small comfort, that the ills the world now suffers are due to perversions of science—the same could be said of religion and even of the good-

ness that keeps whispering in our own hearts.

Many scientists were pondering deeply on the causes of the grave problems civilization must immediately face. Within their own memories—within 40 years—there have been more advancements in science than in all the previous history of the world! And education has been extended everywhere by leaps and bounds! In this period high-school graduates in our country have increased tenfold; college graduates, fivefold; the doctor's degree, eightfold; library facilities, sevenfold; university endowments, twelvefold. And what is the result?

As facilities for production have been improved by applications of science, increasing numbers of people have suffered want—"one third of our people are ill fed, ill housed, and ill clothed." Ten millions are out of work and billions of dollars are being spent for relief. In spite of all the means science has provided for creating wealth, our per capita public debt has increased twenty-fold in a generation. On every hand there are pressure groups for larger gratuities and special favors, ranging from the Youth Congress to tottering Townsendites; from farmers to factory workers. As education has increased, dissatisfaction, disillusionment and cynicism have also increased. One is inclined to sing "Lead, kindly light, amid the encircling gloom."

Such are natural thoughts in times of extreme stress, but they are morbid thoughts, unbalanced, incorrect. For every unfavorable new condition there are two of the opposite character. Even the losses of life in war are many times overbalanced by the saving of life through sanitation and medicine. Armies strike down, but thousands of organizations raise up—churches, schools, clubs, Boy Scouts, 4-H clubs, hospitals, social centers, the Red Cross, etc.

Although scientists realize the seriousness of present world conditions, they have no fear that the human race will become biologically exhausted; it is increasing in numbers with great rapidity and probably on the whole in physical vigor. They do not fear that civilization will be destroyed or pass into a long eclipse; it has much too great vitality. But they do realize that science has suddenly placed mankind in a new and much

SUMMER MEETING HEADQUARTERS OF THE ASSOCIATION

DANIEL BAGLEY HALL, HOME OF THE DEPARTMENT OF CHEMISTRY AND THE COLLEGE OF PHARMACY.

GROUP OF BUILDINGS OF THE UNIVERSITY OF WASHINGTON
Left to right: CONDON HALL, HENRY A. SUZZALLO LIBRARY AND PHILOSOPHY HALL.

more complex environment than the old, requiring many readjustments and reorientations that may be long in the making.

For these reasons scientists no longer assume that their scientific work simply adds to a world that otherwise remains the same, but normally all their science will be joined in their thoughts with its effects on civilization. More frequently in the future programs of the association will be essentially, if not formally, on Science and Society.

F. R. MOULTON

LEO H. BAEKELAND AND ARTHUR H. COMPTON, FRANKLIN MEDALISTS

DISTINGUISHED contributions in the fields of applied science and of pure science received equal recognition recently when the Franklin Institute bestowed its highest award, the Franklin Medal, upon Leo Hendrik Baekeland, inventor of the synthetic resinous substance, bakelite, and upon Arthur Holly Compton, whose work on the properties of x-rays has won him renown throughout the scientific world.

Though Dr. Baekeland is best known for his invention of bakelite, he has made significant contributions in other fields. A native of Belgium, Dr. Baekeland came to the United States in 1889. After a short period during which he was employed as chemist by A. and H. T. Anthony and Company, then the largest photographic supply house in the United States, Dr. Baekeland and Mr. Leonard Jacobi founded the Nepera Chemical Company, located in Yonkers, New York, for the manufacture of photographic papers and chemicals. One of the products of this company was "Velox" paper, which constituted a distinct step forward in the art of photographic printing. In 1899 the company sold out to the Eastman Kodak Company and Dr. Baekeland turned his attention to chemical research. One of his achievements during the period of consultation work which followed was the development to the commercial stage of C. P. Townsend's invention of an electrolytic process for producing caustic soda and chlorine from a solution of common salt.

Dr. Baekeland's most important work has been in connection with the chemical

Photograph by Gladys Müller

AFTER THE PRESENTATION OF THE FRANKLIN MEDAL

DR. LEO H. BAEKELAND EXAMINES THE MEDAL WHICH HAS JUST BEEN PRESENTED TO HIM BY MR. PHILIP C. STAPLES, PRESIDENT OF THE FRANKLIN INSTITUTE, WHILE DR. KARL T. COMPTON LOOKS ON. DR. COMPTON ATTENDED THE CEREMONIES TO RECEIVE THE FRANKLIN MEDAL AWARDED HIS BROTHER, DR. ARTHUR HOLLY COMPTON, OF THE UNIVERSITY OF CHICAGO.

reaction between carbolic acid and formaldehyde. By heating the product of this reaction under pressure, he turned the viscous mass into an insoluble solid with an appearance like amber or ivory, which could not be melted again, was easy to mold, was resistant to moisture and to chemical reagents and which did not conduct electricity. This invention was the beginning of the modern plastics industry, the products of which are so widely used to-day.

Dr. Baekeland has received many honors and awards. He has been the recipient of the Nichols Medal, the Willard Gibbs Medal, the Chandler Medal, the Perkin Medal, the John Scott Medal and the Messel Medal.

The award to Dr. Compton was in recognition of his brilliant experiments on various properties of x-rays, some of which involved new methods of attack, and, in particular, for his discovery and theoretical treatment of the Compton Effect.

Dr. Arthur H. Compton graduated from the College of Wooster in 1913. Ten years later he was professor of physics at the University of Chicago, occupying one of the most important professorships of physics in the country, which position he still holds. During the interim he had obtained his degree of doctor of philosophy from Princeton University, held the position of instructor in physics at the University of Minnesota for a year, spent two years as research physicist with the Westinghouse Lamp Company, one year at the Cavendish Laboratory in Cambridge as a National Research Fellow, and three as professor of physics at Washington University. Dr. Compton has been the recipient of many honors and awards, including the Nobel Prize in physics in 1927.

Photograph by Gladys Müller

THE FRANKLIN MEDAL AWARDED TO DR. A. H. COMPTON

THE GOLD MEDAL, DESIGNED BY THE LATE R. TAIT MCKENZIE, IS TWO AND ONE HALF INCHES IN DIAMETER.

Dr. Compton's early work on the total reflection of x-rays incident upon a metallic surface at a very small angle led to a new method of measuring the wave-length of x-rays, namely, the ruled grating method, the results of which are now regarded as more exact than those obtained by the earlier crystal method of Bragg—results from which have been calculated more reliable values of fundamental physical constants.

In 1923 Dr. Compton investigated the nature of x-rays which had been scattered by matter. For such scattered rays the

Photograph by Gladys Müller

A GROUP OF THE MEDALISTS

Seated, left to right: LAURENS HAMMOND, MAXWELL M. UPSON, PHILIP C. STAPLES, PRESIDENT OF THE FRANKLIN INSTITUTE, RICHARD L. TEMPLIN AND EDWARD E. KLEINSCHMIDT. *Standing, left to right:* GAMES SLAYTER, FREDERICK M. BECKET, ROBERT R. WILLIAMS, JOHN F. FLAGG, WILLIAM E. WOODARD, DR. HENRY B. ALLEN, SECRETARY OF THE FRANKLIN INSTITUTE, LEOPOLD D. MANNES, LEOPOLD GODOWSKY, JR., CHARLES ROSENBLUM AND HOWARD L. KRUM.

old electromagnetic theory predicted no change of wave-length, whereas the new quantum theory predicted a modification in wave-length. Dr. Compton's photograph showed the existence of both types of ray. He explained the modified wave-length as due to a collision of an x-ray photon with a free electron, the photon bouncing off in one direction with a changed wave-length and the electron recoiling in an opposite direction. Application of the quantum theory led to equations which checked with experiment. Thus Dr. Compton not only discovered a new phenomenon, which now bears his name, but also gave its correct theoretical interpretation—a dual feat of great brilliance.

In recent years Dr. Compton's chief work has been in the field of cosmic rays. From his world-wide survey in the early 1930's, he concluded that these rays are largely composed of enormously energetic electrified particles. Other cosmic ray problems are being attacked systematically by Compton with the assistance of other observers in various parts of the world.

These awards of the Franklin Medal were presented at the exercises on the Franklin Institute's Medal Day, at which time Cresson Medals were awarded to Frederick M. Becket, of the Union Carbide and Carbon Corporation, for his development of low carbon ferro-alloys and his contributions to electrometallurgy, and to Robert R. Williams, chemical director of the Bell Telephone Laboratories, New York, for his researches upon Vitamin B_1, including its isolation in the pure state in quantity sufficient for further chemical study, the identification of its segments and its synthesis in quantity. On the same occasion Wetherill Medals were awarded to Laurens Hammond for his electric organ,

and Edward E. Kleinschmidt and Howard L. Krum for their work in the development of the teletypewriter. Longstreth Medals were awarded to Leopold Godowsky, Jr., and Leopold D. Mannes, the inventors of Kodachrome film; Games Slayter, of the Owens-Corning Fiberglas Corporation, for his improved methods and apparatus for producing glass filaments; Richard L. Templin, of the Aluminum Company of America, for his deformation recorder; and Maxwell M. Upson, of the Raymond Concrete Pile Company, for his contributions to the scientific development of foundation engineering and construction.

The Henderson Medal, presented for distinguished contributions in the field of railway engineering, was awarded to William E. Woodard, of the Lima Locomotive Works, in consideration of his accomplishments in locomotive engineering and his important contributions in the field of steam locomotive design. The Levy Medal, awarded for a paper of especial merit published in the *Journal of the Franklin Institute*, was presented to Charles Rosenblum, of Princeton University, and John F. Flagg, of the University of Rochester, for their paper entitled "Artificial Radioactive Indicators."

John Frazer

AN EXPEDITION TO STUDY BIG-GAME FISH

One of the most extensive undertakings ever attempted in the study of big-game fishes has been under way for several years by the Michael Lerner-American Museum of Natural History Expeditions. The large, pugnacious game-fishes, such as broadbill swordfish and the various species of marlin, have

MEMBERS OF THE BIG GAME FISH EXPEDITION AT TALARA, PERU

Front row, left to right: VIBO VALENZIO, IRVING HARTLEY, DAVID DUNCAN. *Back row, left to right:* CAPTAIN DOUGLAS OSBORNE, HELEN LERNER, MICHAEL LERNER, FRANCESCA LAMONTE, CAPTAIN BILL HATCH.

continued to be baffling mysteries as to their breeding habits and migrations. A new expedition under the same sponsorship has now extended its field research to the Humboldt Current waters off the coasts of Peru and Chile. These expeditions have journeyed to the far corners of the world each summer since 1936, and although satisfactory advances have been made in the knowledge that has been attained, there are still many missing links in the chain of evidence.

The Peru-Chile expedition is the fifth one conducted by Michael Lerner for the American Museum of Natural History in association with members of the museum's scientific staff. From 1936 to 1938 Lerner expeditions studied the Atlantic coast swordfish off Louisburg, Cape Breton, and the marlins in the waters off Bimini. Last year runs of the Pacific species of these fish were investigated off New Zealand and Australia. The object of the 1940 expedition in going to Peru and Chile is to determine if the swordfish and marlin there are the same as those found in western Pacific waters.

Research of this type has to be done in the field because of the difficulty in transporting huge fish to museum laboratories. To insure a continuous supply of fresh specimens for scientific study, swordfish and marlins are collected on rod and reel by Mr. and Mrs. Lerner, both experienced big-game anglers of world-wide renown. Miss Francesca LaMonte, associate curator of the Department of Ichthyology, is the scientific leader of the expedition. She conducts studies in the field, for stomach contents, sex and parasites, all of which provide clues for the solution of the mysteries regarding the homes and habits of these fish.

One of the most remarkable facts about broadbill swordfish is that they seem to be the same all over the world in appearance and anatomical structure. This, however, does not apply to the marlins, which run in the same waters. It is important to find out how to tell one kind of marlin from the other. There are blue, black, white and striped marlins, and until they can make a thorough examination of large numbers of all these varieties they can not tell whether there are seven or eight kinds of marlins or whether there are only two or three despite differences in coloring and markings. Previous studies of marlins made by the Lerner expeditions in the Gulf Stream and in Australia and New Zealand have recorded the differences in color patterns, body forms and fins. In the present expedition field laboratories will be established at Talara, Peru, and Tocopilla, Chile, for the further study of the same problem.

On the return trip a stop will be made at Cuba to investigate recent theories that the waters off that island may be breeding grounds for the Atlantic run of both swordfish and marlin.

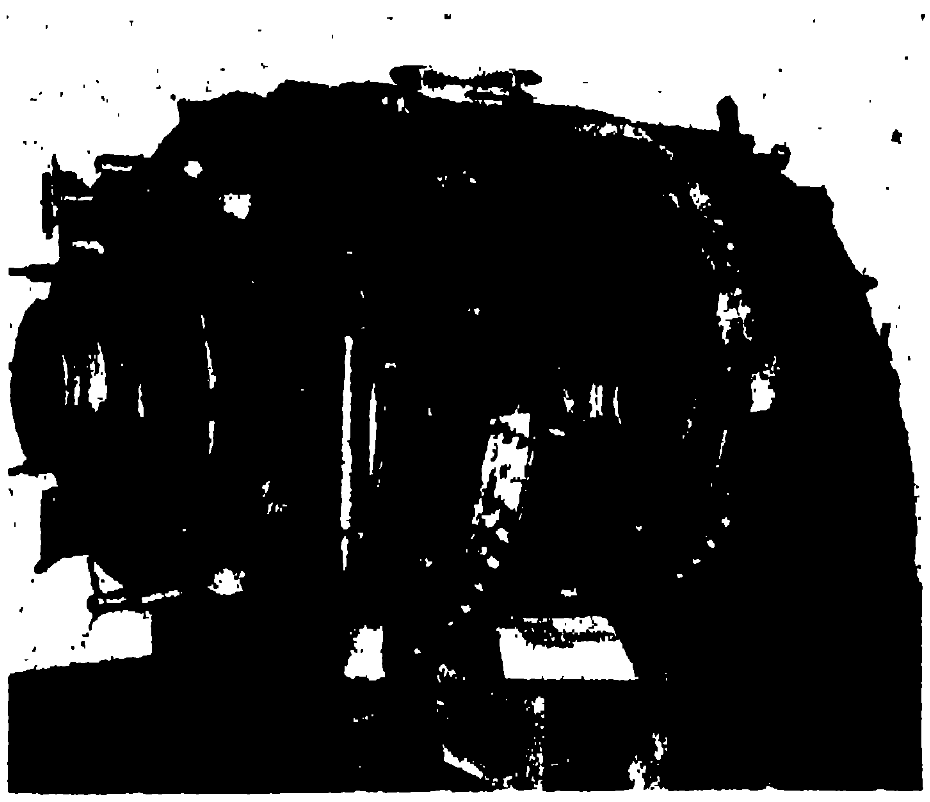
In addition to Mr. and Mrs. Lerner and Miss LaMonte, members of the expedition include the following: photographers, Irving Hartley, of New York City, and Vibo Valenzio, of Ozone Park, L. I.; fishing guide captains, William Hatch and Douglas Osborne, of Miami, Fla.

WILLIAM K. GREGORY

OXYGEN REQUIREMENTS AT HIGH ALTITUDES

COLONEL LINDBERGH, in a report to Congress, emphasized the necessity of increasing the facilities in this country for research in the various fields connected with aviation. Of these fields none has been more neglected than that of aero-medical research.

While the effects of anoxemia (insufficient oxygen) at high altitudes have been long recognized, it is only within the last two or three years that any material advance has been made in perfecting apparatus for the administration of oxygen to pilots, crew and passengers of



PRESSURE CHAMBER
WITH TECHNICIAN AT CONTROLS OBSERVING AND TALKING BY TELEPHONE TO SUBJECTS INSIDE.

airplanes. The studies of Boothby, Lovelace and Bulbulian, which led to the development of a comfortable type of apparatus that required only one quarter to one fifth as much oxygen per minute per individual as had been previously required, have led to substantial progress on one of the many practical problems that need immediate attention.

Another important problem that must be clarified as soon as possible is that concerned with rapidity of ascent. Airplanes are being constructed which are reported to be able to ascend at the rate of about a mile per minute. How fast can the human body be decompressed from full nitrogen saturation at sea level? Can the tables of decompression first worked out by Haldane and recently modified by Lt. Commander C. B. Momsen, Lt. A. R. Behnke and their associates in the Laboratory of the Experimental Diving Unit, Navy Yard, Washington, D. C., be extrapolated to pressures of less than one atmosphere? Is it possible that the timetable of decompression can be safely shortened in aviation by preliminary decompression with oxygen? Even at full saturation at one atmosphere, the mass of nitrogen in the tissues will be only a fourth that at four atmospheres, as in diving operations; therefore, when bubbles form, the amount of such bubbles will be smaller and possibly less likely to cause serious injury. Even if bubbles in the blood stream do cause trouble, will immediate recompression by descent remove the ill-effects with sufficient rapidity to prevent a crash?

These and many other problems need immediate investigation, and for these

ANALYZING ALVEOLAR AIR
METHOD OF OBTAINING AND COLLECTING SAMPLES TO CHECK AMOUNT OF OXYGEN REQUIRED PER MINUTE WHEN USING THE B. L. B. INHALATION APPARATUS IN ORDER TO MAINTAIN A NORMAL PARTIAL PRESSURE OF OXYGEN IN THE LUNGS AT ALL ELEVATIONS.

INSIDE THE CHAMBER
OBSERVATIONS BEING MADE BY THE TECHNICIAN ON A SUBJECT LYING DOWN IN THE CHAMBER; BOTH ARE OBTAINING OXYGEN BY USE OF THE INHALATION APPARATUS.

purposes the Mayo Foundation has installed a pressure chamber in the Laboratory of Metabolic Investigation in which both low and high pressures can be developed with sufficient rapidity to obtain data upon these points. Other phases of aero-medical research will be studied, especially from the point of view of prevention, not only in the normal and adaptable individual but also in aged and sick persons. The precautions and facilities necessary to transport patients safely by air must also be investigated.

J. R. M.

THE BRINE-SHRIMP ARTEMIA AND ITS ENVIRONMENT

A NUMBER of small organisms inhabit salt lakes in the desert and brine pools which occur along the ocean shore in regions of low rainfall where salt is concentrated by solar evaporation. One of the most conspicuous of these is the brine-shrimp *Artemia,* which is found in water more saline than the sea in many parts of the world. Under protected conditions in the laboratory it thrives and completes its life cycle in sea water, but it is defenseless against marine predators which prize it highly as food. In nature *Artemia* capitalizes on its unusual ability to withstand extreme conditions and develops in great numbers in water so saline or alkaline that enemies can not follow. *Artemia* are abundant in the Great Salt Lake, which contains a salt mixture much like that of the sea except that it is more than seven times as concentrated. They are also very abundant in Mono Lake, which is highly alkaline.

In "Roughing It," Mark Twain (with a very considerable degree of exaggeration) describes the effects of Mono Lake water on a dog with sores which made a mistake in judgment and jumped in. There was soon no bark left, inside or out, but the dog reached shore and struck out over the mountains. Mark Twain wrote that nine years later it was still going. He also describes the *Artemia* and notes their great abundance. Without exaggeration, it can be stated that *Artemia* may swim about for ten or fifteen minutes in undiluted Bouin's fluid (picric and acetic acids and formaldehyde). Oddly enough, *Artemia* is relatively intolerant of potassium, and its distribution in the American desert is affected by this factor. It has been reported that it will hatch throughout the pH range 2 to 13.

Artemia is a primitive arthropod of the class Crustacea. The adult body is divided into a large number of segments, and there are many appendages adapted for swimming. The size and morphology of *Artemia* varies greatly with the salinity of the habitat, but the adult is commonly about half an inch long.

Small salt lakes and brine pools often dry up completely, and this is fatal to the adults and active young. Deserts are also subject to extremes in temperature. The *Artemia* are prolific, and the species of the western United States reproduce in two ways. Actively growing larvae are released from the uterus of the mother as nauplii, but at other times embryos are encased in a heavy chitinous shell which is secreted by the oviduct of the mother. These heavily encased embryos, which are often called cysts, are inactive and may be dried without harm. In fact, it is beneficial if not essential for them to be dried before they will hatch out as nauplii and resume development in a suitable liquid medium. The cysts, which are about one fifth of a millimeter in diameter, may hatch after a number of years in the dry state, and they maintain the *Artemia* in temporary salt lakes and ponds. The cysts also adhere to the feathers of water birds and serve as a very effective means of dispersal. Whenever a new salt pond is established, *Artemia* are apt to appear even if the nearest known source of *Artemia* is far away. So commonly are they associated with brine pools that some salt-makers are said to believe that

salt can not be made from sea water without them.

In some localities adult *Artemia* are collected in large quantities and fed to tropical and other aquarium fishes. The cysts are also collected and distributed commercially to fish fanciers who can hatch them conveniently at any time to provide a highly prized living food.

Protoplasm which is relatively dehydrated is generally resistant to extreme temperature and, since this condition is associated with an inactive state, to lack of oxygen as well. The dry *Artemia* cysts are no exception. It has recently been shown that they may be submerged in liquid air, at $-190°$ C., for 24 hours without affecting the rate of subsequent hatching, or the percentage which hatch. Cysts have also been maintained in high vacuum (10^{-6} mm Hg), so far for six months, with the same result. Since the high vacuum deprives the cysts of moisture as well as oxygen, it appears that no degree of desiccation is too great for them. The fact that they can survive without oxygen for at least six months indicates that their resting metabolism may be reduced to an extremely low level.

Douglas Whitaker

STRANGER THAN FICTION

At a conference of astronomers held in Paris a year ago, Dr. G. P. Kuiper, of the Yerkes Observatory staff, announced the discovery of a star, known as Wolf 457, whose average density is about 500,000,000 the density of water. This is the densest matter known. A cubic inch of it at the surface of the earth would weigh about 9,000 tons!

The mass of the sun is about 330,000 times that of the earth. The mass of the dense star is about 20,000,000 times that of the earth, or 60 times that of our sun. Yet it is smaller than the moon, its diameter being only 3,000 miles. An object on its surface would weigh 55,000,000 times as much as it would on the surface of the earth. A cubic inch at the average density of the star at its surface would weigh 55 million times 9,000 tons or 495 billion tons.

The star is so small that it would be quite invisible even through large telescopes if its surface were not extremely luminous, as it is because its surface temperature is about 30,000 degrees Centigrade, or about five times the surface temperature of the sun. Since the rate of radiation of a luminous body varies as the fourth power of its temperature, the surface brightness of this remarkable star is about 600 times that of the sun.

Ordinarily the nature of a substance is determined from examinations of various of its properties, as its color, hardness, specific gravity, chemical reactions, melting point, etc. But all that is known about this dense star is inferred from the faint light that is received from it, for at a distance of many light years it is quite beyond the reach of all senses except that of sight. Yet the light of a star generally carries more information than many a bulky tome filled with the crude characters that are used in attempting to express what is in some muddled mind. With almost unerring precision it reveals the temperature of the radiating source, the chemical constitution of it and its state.

By its state I mean in part the extent to which its atoms are stripped of its outer electrons. In this remark is the principal key to the explanation of the very dense stars. For some reason not yet known the atoms of these stars have lost their far-wandering electrons that ordinarily give them bulk, and they consist only of their exceedingly dense central parts. Therefore they lie close to one another somewhat like shot in a pile.

Is this only a dream? It is hardly more questionable than nearly everything that we accept as certain. In comparison with it general philosophical principles and theological doctrines are extravagant extrapolations from experience. But our minds have become accustomed to them,

whereas matter millions of times as dense as water is a stranger to us and therefore to be rejected.

Not long ago the possibility that the earth has existed for many millions of years seemed equally fantastic and only 25 years ago even astronomers recoiled from the suggestion that our galaxy is composed of billions of stars and that there are exterior galaxies so far away that light from them is on its way millions of years before it reached us. How sure we are of the familiar and how fearful of the unknown. F. R. M.

EFFECTS OF SULFANILAMIDE ON TOBACCO PLANTS

SULFANILAMIDE is undoubtedly one of the most important artificial chemical compounds that has ever been placed at the disposal of medicine. During the past three years it and its related compounds have been found to produce beneficial, and in some cases remarkable, effects in a wide variety of bacterial diseases. In recognition of the importance of these new chemicals, the discoverer of some of the therapeutic properties of sulfanilamide, Dr. Gerhard Domagk, of Germany, has recently been awarded a Nobel prize in physiology and medicine.[1]

It is, of course, very gratifying to medical men that the sulfanilamide group of compounds has remarkable curative properties for animals infected with quite different kinds of bacteria. But this fact proves that the action is not *specific,* in the sense that various kinds of bacteria are stained only by different kinds of dyes, doubtless as a consequence of definite chemical interactions between the dyes and certain of the many chemical constituents of the organisms. Nor is the action *general* in the sense that it has destructive effects upon all organic tissues, as strong acids and alkalis have, for if it were general these compounds would be destructive to the host as well as to the infecting organisms. As a matter of fact, it is not yet known just why the sulfanilamide compounds cure any disease. When the mode of their action is finally understood, wide new doors of progress may be opened to medicine.

Since bacteria are low forms of plants, it might be suspected that the sulfanilamide compounds would have marked effects upon higher plants. This would be at the most only a suspicion, however, because these chemicals have much less marked effects upon bacteria in the test-tube than in the animal host. It is generally believed that the action upon the organisms is not direct but that in some way the infected animal participates in it.

In order to throw light upon these questions, Dr. Ernest L. Spencer, of the Rockefeller Institute for Medical Research, has been investigating the effects of sulfanilamide on seedlings of Turkish tobacco plants. He finds several interesting results. The first is that sulfanilamide is a very effective growth-promoting substance, stimulating root proliferation on cuttings of the plants, but not on uncut seedlings. The second effect is that tobacco seedlings are extremely sensitive to the toxic effects of these chemicals. Strangely, concentrations of sulfanilamide which stimulated root formation in cut plants were strongly toxic to plants with normal root systems. The third notable effect is the nature of the toxic effects, which closely resemble the physiological disease "frenching," which has been known for 250 years.

At the moment the experiments and observations of Dr. Spencer appear to add to the confusion of many unexplained facts. They are, however, additional pieces in the jigsaw puzzle whose eventual assembly will almost certainly result in a new and beautiful pattern, as interesting from the scientific point of view as it will be important from the practical point of view. F. R. M.

[1] See the January issue of this journal.

THE SCIENTIFIC MONTHLY

SEPTEMBER, 1940

UTILIZING SUN RAYS

By Dr. C. G. ABBOT
SECRETARY OF THE SMITHSONIAN INSTITUTION

According to the clearness of the day the sun's beam contains energy at the rate of from 1.0 to 1.5 calories per square centimeter per minute at the earth's surface. On a square meter of surface at right angles to the beam, this corresponds to from 1.02 to 1.52 horsepower per square meter, or to the raising of 0.16 to 0.24 kilograms of water at 20° to steam at 100° C. Thus the counties of Grant, Sierra, Hidalgo and Luna in New Mexico, or the southern part of Florida from a line connecting Sarasota with Fort Pierce, receive as much energy from the sun per year as is used annually for all purposes—power, heat and light—in the United States.

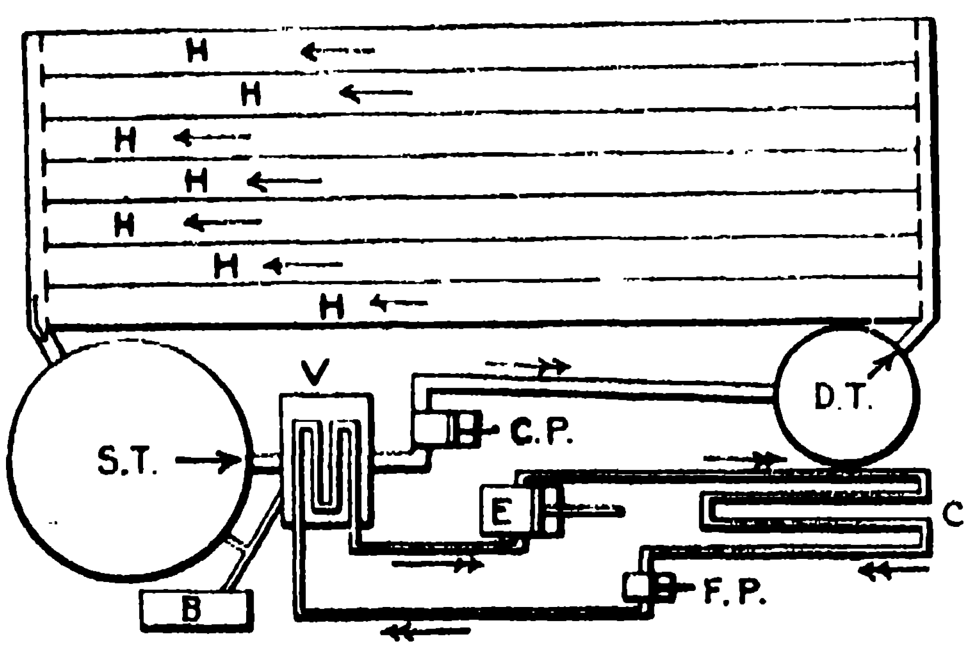
Several drawbacks have hitherto prevented extensive use of solar energy for power and other purposes. They are: First, the considerable area required to collect large quantities of power as compared to other prime moving sources. Second, the wandering of the sun in the sky by day and by season. Third, the intermittence of solar radiation caused by clouds and night. It is true that for some limited purposes, including the evaporation of water and the heating of water for domestic uses, these objections are not very serious. But for the main object, solar power, they are all of consequence. Two devices have indeed been used with some success to avoid following the wanderings of the sun in the sky. Willsie and Boyle, about thirty-five years ago, developed the use of a shallow black-bottomed pond of water to absorb heat sufficient to operate a sulfur dioxide engine at a low temperature. Their plant at Needles, Arizona, is described in *Engineering News*, May 13, 1909. On account of the considerable inclination of solar rays, the reflection from the surface of the pond and its glass cover and the low thermodynamic factor associated with the low temperature, their efficiency factor was, of course, very low, so that the area required per horsepower was fully a hundred times that given above. On the other hand, the heat collector was relatively inexpensive.

Giovanni Andri, of Milan, has installed a number of solar power plants in Italy and Africa in which the heater is a blackened flat metal box, having a limited adjustment about a horizontal axis, and also operating a low-temperature engine. Except for reflection, the considerations just mentioned for the black-bottomed pond will probably apply to his device, although I have no exact information as to its performance.

Of devices intended to follow the sun, the two most noted of recent times are that of A. G. Eneas, employed about thirty-five years ago to pump water at South Pasadena, and that of the Eastern Sun Power Limited, near Cairo, Egypt, used for irrigation in 1913 (see Smith-

GENERAL VIEW FROM SOUTH OF SHUMAN-BOYS ABSORBER, MEADI, 1913

THIS DEVICE WAS ERECTED BY THE EASTERN SUN POWER LIMITED NEAR CAIRO, EGYPT, AND OPERATED IN 1913 IN CONNECTION WITH A STEAM ENGINE FOR PUMPING WATER FROM THE NILE FOR IRRIGATION PURPOSES. THE SUN'S RAYS SHINING UPON THE LONG TROUGH-LIKE MIRRORS WERE REFLECTED TO FOCUS UPON A METAL STEAM BOILER TUBE WITH A WEDGE-SHAPED CROSS SECTION, AND THE STEAM FROM A SYSTEM OF MIRRORS WAS COLLECTED IN THE STEAM PIPE LEADING TO THE ENGINE. THE ENGINEERS CLAIMED AN EFFICIENCY GREAT ENOUGH SO THAT THE DEVICE COULD PRACTICALLY COMPETE WITH COAL IN THAT COUNTRY FAR FROM MINES.



WILLSIE SUN POWER PLANT

WATER FROM THE DISTRIBUTING TANK D. T. AFTER FLOWING THROUGH THE GLASS-COVERED TROUGHS H. H. H. ABSORBING SOLAR HEAT IS STORED IN THE STORAGE TANK S. T. THIS HOT WATER GIVES UP ITS HEAT IN THE VAPORIZER V AND IS SENT BACK BY THE CIRCULATING PUMP C. P. TO THE DISTRIBUTING TANK. SINGLE-HEADED ARROWS INDICATE THE FLOW OF THE WATER. EMERGENCY STEAM BOILER, B, FOR CLOUDY PERIODS. SULFUR DIOXIDE FLOWS IN THE DIRECTION OF THE DOUBLE-HEADED ARROWS FROM THE VAPORIZER COILS TO THE ENGINE E. THE EXHAUST VAPOR GOES TO THE CONDENSER C. THE LIQUID SULFUR DIOXIDE IS RETURNED BY THE FEED PUMP F. P. TO THE VAPORIZER. THE DISTRIBUTING TANK IS SMALL.

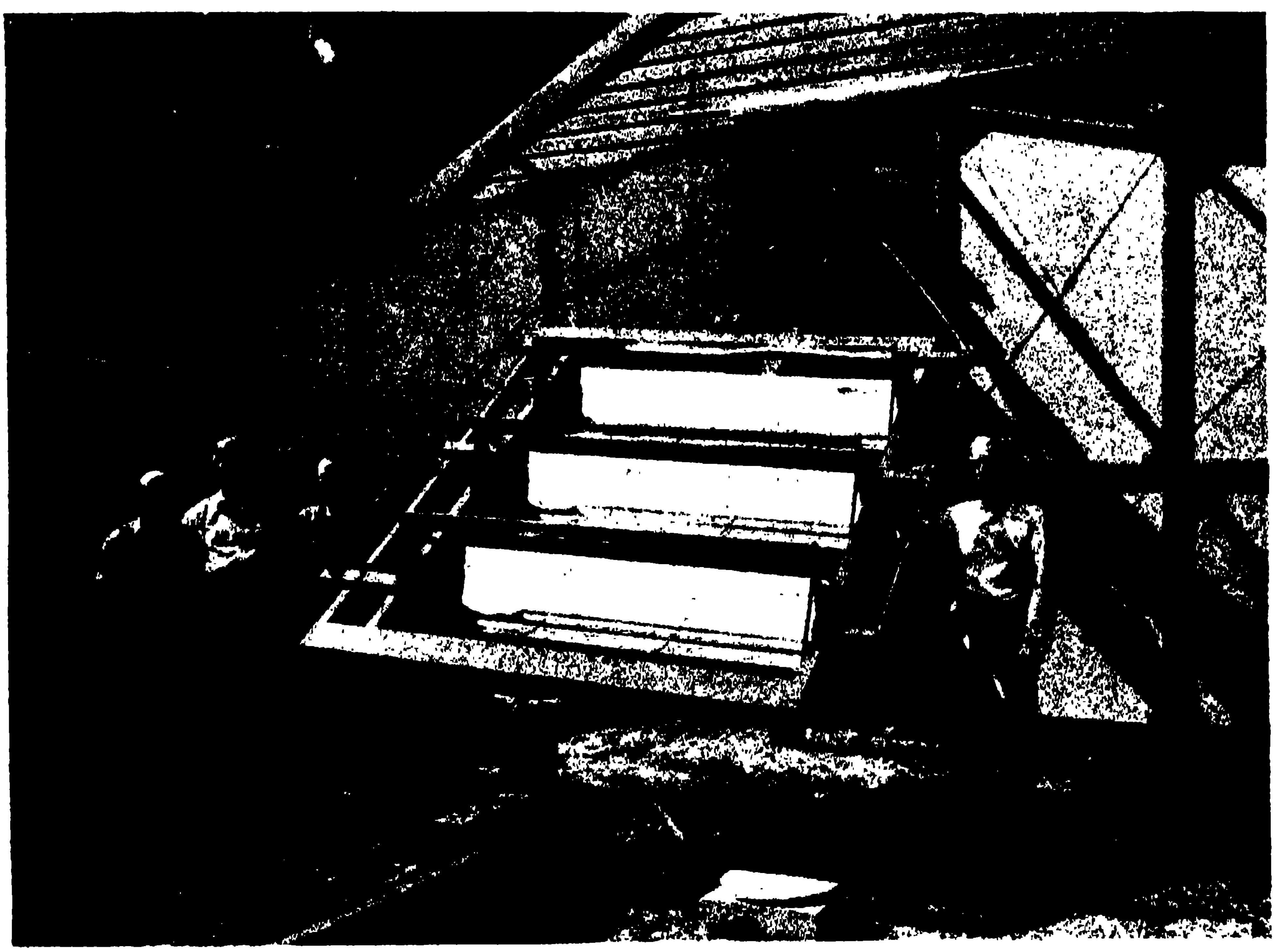
sonian Report, 1915). Mr. Eneas had a conical frame of steel, some 30 feet in diameter, lined with glass mirrors, and mounted to follow the sun both from east to west daily, and from north to south seasonally. A boiler in the focus raised steam for power. However, the machine was too complex and costly for commercial success. The English development near Cairo came nearest to commercial success of any, unless possibly the blackened pond of Willsie and Boyle. It employed cylindrical metal mirrors to raise steam in long tubular boilers at their foci, and rotated the mirrors about horizontal axes to approximately follow the sun from east to west daily.

In recent times the advances in development of aluminum alloys, and in vacuum technique, have greatly simplified the design of efficient solar power devices. With these industrial advances is to be combined an application of long-established astronomical practice to pro-

duce a cheap and effective solution of the solar power problem.

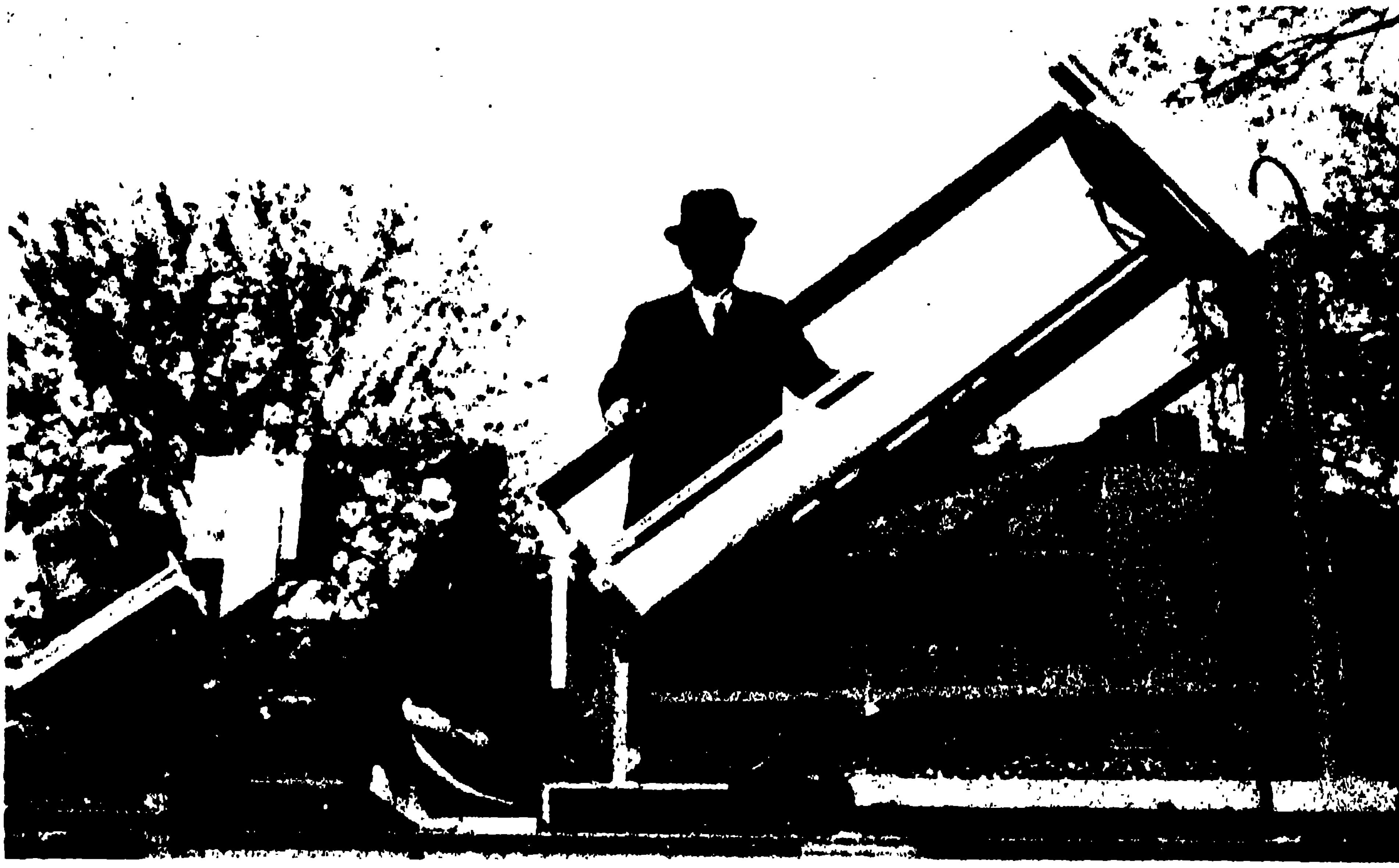
It is familiar to astronomers, though, as patent records show, not so much so to engineers, that the simplest way to follow the sun in its daily course is to mount the device to rotate 15° per hour about an axis parallel to the axis of the earth. For large installations, covering square yards rather than square inches, mirrors are far cheaper than lenses. As for also following the sun from north to south from June to December, this involves, at simplest, motions about two axes, and requires means of transferring heat from a moving boiler to a stationary engine. Hence, it is best to make no provision for the motion north to south, and to use an elongated cylindrical mirror of parabolic section reflecting the sun rays upon a heater tube parallel to the axis of the earth. Part of the mirror is lost except on March 21 and September 21, but this loss is not serious.

The mirror is to be rotated about the center of the heater-tube itself as an axis. In the solar cooker on Mount Wilson, Calif., I used a weight to rotate a mirror of about 100 square feet capacity, regulating its motion by means of an ordinary alarm clock. But where 60-cycle electric current is available it is neater to use a



HALF HORSEPOWER SOLAR ENGINE

AS EXHIBITED TO THE INTERNATIONAL POWER CONGRESS. IN THIS DEVICE THE MIRRORS OF ALCOA SHEET WERE MOUNTED EAST AND WEST IN A FRAME WHICH TURNED ON AN AXIS PARALLEL TO THAT ON THE EARTH. THE SOLAR RAYS STRIKING THE MIRRORS WERE BROUGHT TO A FOCUS ON ELONGATED THERMOS BOTTLES CONTAINING THE HIGH BOILING POINT LIQUID "AROCLOR." THE HEATED LIQUID PASSED BY GRAVITY CIRCULATION TO A BOILER AT THE REAR FROM WHICH THE STEAM PASSED THROUGH A SMALL OPENING. A FEW DAYS LATER THE NATIONAL BROADCASTING COMPANY MADE A COUNTRY-WIDE BROADCAST FROM THIS DEVICE.



FLASH BOILER AND TOY SOLAR COOKER

THE PRESENCE OF ROLLING CLOUDS IN THE SKY FREQUENTLY SPOILS AN OTHERWISE EXCELLENTLY CLEAR DAY FOR THE LARGE APPARATUS, FOR THE LARGE CAPACITY OF HEAT OF THE BOILER REQUIRES A LONG TIME TO RAISE STEAM TO THE PROPER PRESSURE. A FLASH BOILER HAS THEREFORE BEEN DEVELOPED IN WHICH THE BOILER TUBE HAS A VERY SMALL CAPACITY FOR HEAT, AND WATER IS INTRODUCED ONLY AS FAST AS THE STEAM IS MADE. IN THIS APPARATUS THE MIRROR IS MOUNTED ON AN AXIS PARALLEL TO THE AXIS OF THE EARTH AND IS ROTATED BY A WHEEL MECHANISM DRIVEN BY A 60-CYCLE SYNCHRONOUS MOTOR. FULL PRESSURE OF STEAM IS RAISED WITHIN FIVE MINUTES OF THE TIME THE SUN BURSTS OUT OF THE CLOUDS. IN FRONT OF THE FLASH BOILER IS SHOWN THE TOY COOKING APPARATUS IN WHICH LITTLE GIRLS BAKE DOLLS' CAKES AND LITTLE BOYS SEE SMALL SOLAR ENGINES IN OPERATION.

worm-and-wheel drive, operated by a synchronous motor. A large, well-balanced mirror, supported on rollers, can be moved thus with the expenditure of less than 1/1000 horsepower in electricity.

For the construction of the mirror, a cradle of duralumin, having a parabolic cross section, is made. To this is clamped down by metal straps thin sheets of "Alcoa," of highly reflecting and permanent surface, which is now a commercial article by the Aluminum Company of America. Such a mirror reflects about 80 per cent. of solar radiation. I have several such mirrors, now five years old, which, despite dust and an occasional wetting, now polish off with absorbent cotton apparently as brightly reflecting as ever.

The stationary heater-tube of blackened metal, about which the mirror rotates, passes through hollow trunnions. It is closely surrounded by a vacuum jacket of pyrex glass, in the form of an elongated thermos bottle. In the "flash" solar boiler device, the thermos bottle is closed at the bottom, and water is led into the boiler in a small metal tube which discharges within the lower end. The water flashes into steam, which exists above the top of the mirror towards the engine.

In the solar distilling device, there is a

reservoir for the water to be distilled at the level of the upper part of the mirror. A snout-tube passes downwards parallel to and under the mirror, turns upwards at right angles and again bends at right angles as a gigantic U to form the blackened heater-tube. Inside of the heater-tube there returns through the U, and quite through the water of the reservoir, a steam tube. There is an opening at the lowest point from the steam tube through the snout where condensed water drips into a receptacle. It will be seen that the water to be distilled is preheated in cooling the steam, so that only the latent heat of evaporation needs to be supplied.

With one solar distillation, I have made, from Atlantic Ocean stock, water so pure that it gives no cloud with silver nitrate. The yield from a mirror of about 11 square feet is about 2 gallons per day, in fine weather. The distiller is automatic, and works whenever the sun shines unclouded.

TOY SOLAR COOKER

SHOWING THE OVEN AND THE ENGINE, AND BELOW THE SMALL MIRROR OF ALCOA SHEET WITH ITS ELONGATED THERMOS BOTTLE THROUGH WHICH THE BLACK HIGH BOILING POINT LIQUID CIRCULATES, AND THE ALARM CLOCK MECHANISM UNDERNEATH WHICH GEARS WITH THE MIRROR.

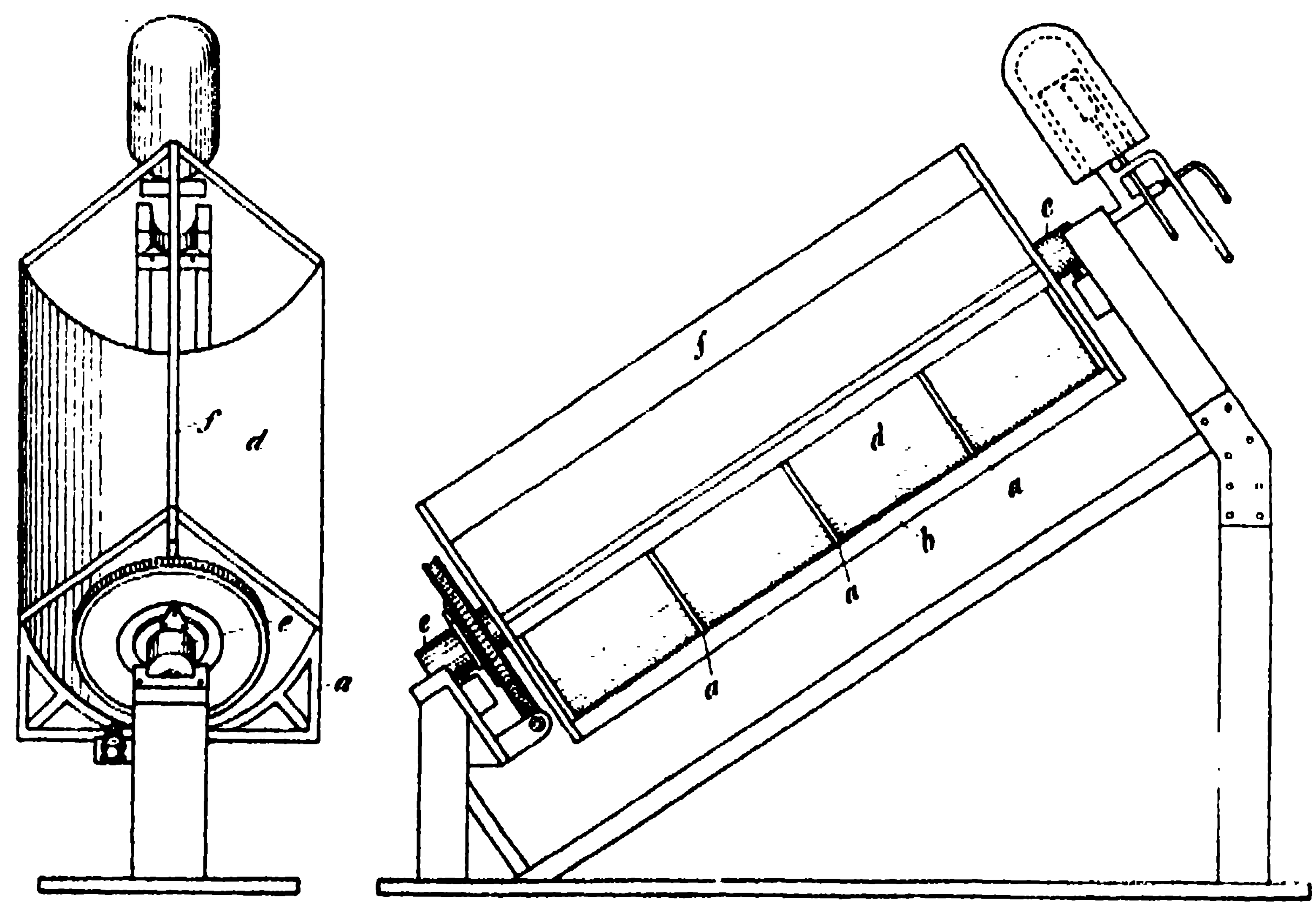


DIAGRAM OF SOLAR FLASH BOILER

THE MIRROR, AAA, IS MOUNTED TO ROTATE ON BEARINGS, E, PARALLEL TO THE AXIS OF THE EARTH. THE SOLAR RAYS COME TO FOCUS ON THE BOILER TUBE, WHICH IS CONCENTRIC WITH THE BEARINGS. THE BOILER TUBE IS OF BLACKENED METAL SURROUNDED BY AN ELONGATED THERMOS BOTTLE LEADING TO THE BOILER. A SMALL STEAM CHEST IS SHOWN AT THE TOP FROM WHICH PIPES GO TO THE ENGINE.

The flash boiler for power purposes is also automatic. The supply of water is governed by the temperature of the boiler tube. Thus as soon as the sun comes out of a cloud, water begins to flow. The stroke of the pump is governed by boiler temperature, and increases as the sun rays grow stronger, until the flow of the water is so rapid that no increase of temperature occurs. I have been accustomed to use steam pressures up to 150 pounds per square inch. Pressure comes to maximum in about 5 minutes, so that days when clear unclouded sky is occasionally beset by cumulus clouds covering the sun are still useful for power.

As a boiler, the efficiency is about 64 per cent. With a thermodynamic factor of 34 per cent. and a turbine efficiency of 75 per cent. the efficiency of converting solar radiation to actual power comes out about 15 per cent. Thus with 4 to 7 square meters of mirror surface, according to the clearness of the atmosphere, there should be yielded 1 horsepower in mechanical work.

When one considers the storage of power to cover times of cloudiness and night, it is obvious that the more cloudy parts of the world will not be used profitably for solar exploitation. But in desert conditions it seems probable that if a flash boiler were connected to a grid of heater pipe within a strong cylinder, superheated water might be accumulated, from which steam could be drawn when direct solar heating is unavailable.

Cooking by solar radiation is readily done. In devices for this purpose I surround the oven with a space filled by a black liquid of high boiling point, and I arrange a gravity circulation between this liquid sheath and a thermos tube, filled with the same liquid, and fixed in the focus of a mirror. The oven is preferably protected from loss of heat by a thick layer of insulation, such as glass wool.

There is great public interest in solar utilization. Letters come almost daily from parties interested in one or more of the uses I have described. But though well-acting models exist of the flash boiler, the solar distilling device and the solar cooker, it has not as yet been possible to undertake production in quantity. Until this is done, it would be hopelessly costly to make these solar devices one at a time. But when wholesale production is accomplished, I believe that solar power can be produced, with fair return on the investment, at not above 0.5 cents per horsepower hour.

CONSERVATION IN PUEBLO AGRICULTURE

I. PRIMITIVE PRACTICES

By Dr. GUY R. STEWART

SENIOR SOIL CONSERVATIONIST, SOIL CONSERVATION SERVICE, U. S. DEPARTMENT OF AGRICULTURE

IN the arid Southwest we find some of the oldest settled agricultural communities in the United States among the twenty-six Pueblo villages. The sketch map, Fig. 1, shows the general extent of the Pueblo country which embraces the southern portions of Utah and Colorado, with the states of Arizona and New Mexico, together with adjacent areas of northern Chihuahua. It is a land with a wide diversity of topography and great variations in local conditions, but the environment presented certain similarities in the problems the early agriculturist had to solve in order to obtain a living. Throughout much of the region high summer temperatures may prevail, although on the upland plateaus, as at Mesa Verde and the Taos Valley, the elevation reduces extreme heat. Over the entire region, however, rainfall has frequently been deficient and at all times is highly variable, so that moisture has been the greatest limiting factor in crop growth. All the settled tribes that have lived in this land of desert and mesa have had a unifying interest; they have been sedentary farmers using a specialized maize agriculture as their principal support, in a country where average conditions are more rigorous than those found in the Dust Bowl.

—*Stewart*

FAR VIEW HOUSE AT MESA VERDE

THE LARGEST CENTRAL PART OF THE GROUP OF VILLAGES, NEAR THE HEAD OF THE FLOOD WATER DITCH ON CHAPIN MESA.

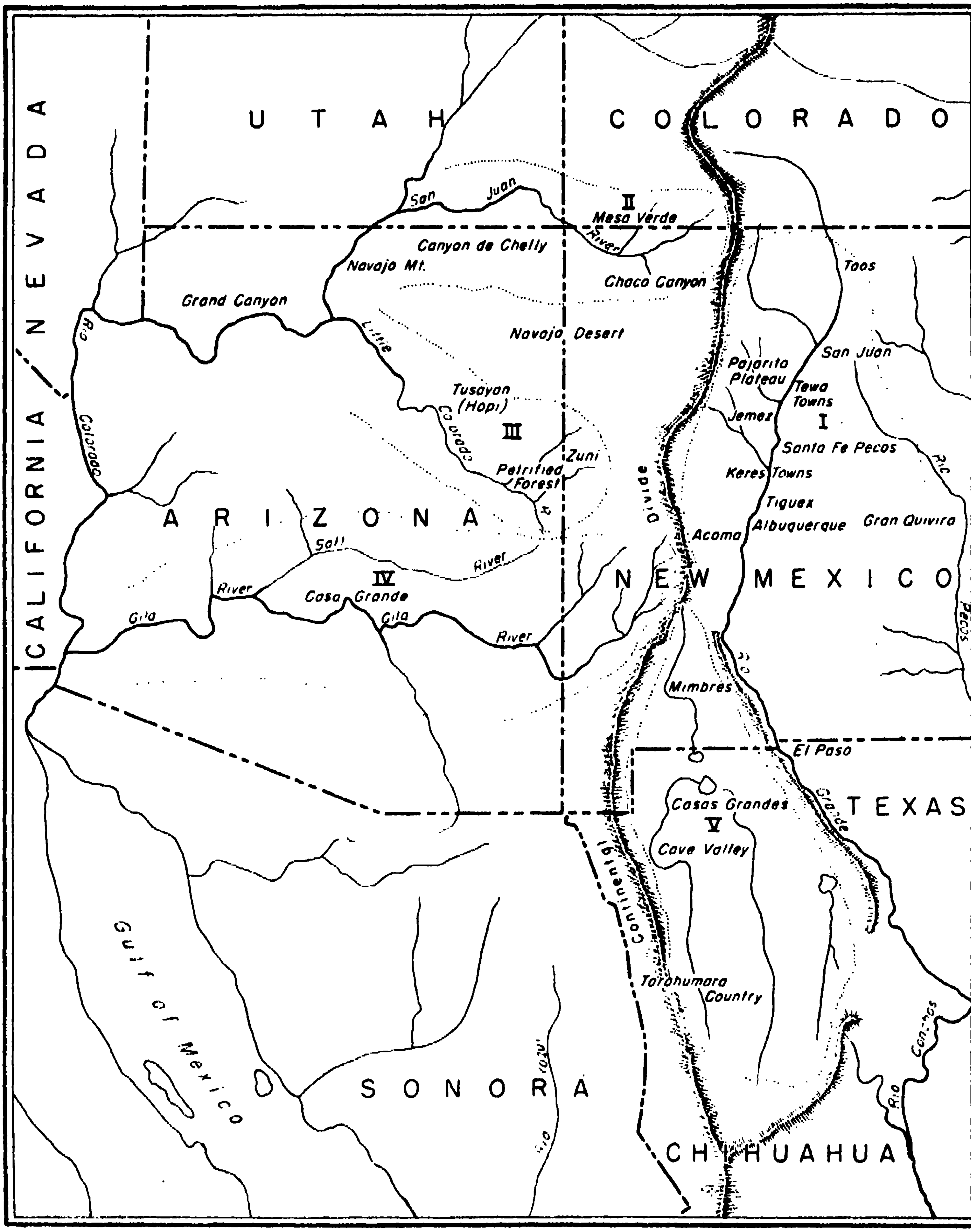


FIG. 1. MAP OF THE PUEBLO PLATEAU

PUEBLO CULTURE AREAS: I—RIO GRANDE; II—SAN JUAN; III—LITTLE COLORADO; IV—GILA; V—MIMBRES CHIHUAHUA. AFTER MAP BY SCHOOL OF AMERICAN RESEARCH.

—*Stewart*

ONE OF THE STRIKING REMNANTS OF THE EARLY MESA TOP
FOUND NOT FAR FROM THE NORTH ENTRANCE TO MESA VERDE NATIONAL PARK.

When Coronado reached Hawikuh, the most southerly of the famed "Seven Cities of Cibola," constituting part of the Zuni group of villages, he was disappointed with the lack of the reputed stores of gold, silver and precious stones. As he explored the Pueblo country he found, however, a group of some eighty agricultural communities with a well-organized system of agriculture. These villages, in fact, had sufficient surplus corn so that Coronado and his three hundred and twenty men, with their native helpers from Northern Mexico, were able to obtain supplies of maize during the two years they remained in the Pueblo land.

The writer has been interested for several years to find what could be learned of the agricultural practices of the early Pueblo tribes, particularly of the use which they made of conservation measures that would conserve water and soil and enable the primitive cultivator to live in this western land with its strong sunshine throughout the year, together with the dry variable winds of the spring and the fall.

Two sources of information have been available; the first of these is the evidence still obtainable around the early sites showing agricultural usage, such as flood water diversion, water retention dams or irrigation ditches, together with records of such usage in the writings of the large group of ethnologists and archeologists who have worked in the Southwest. The second is from the study of the agricultural methods of the present-day Hopi and Zuni tribes who have been the least affected of the Pueblo peoples by Spanish and American influence. Here one can still see the entire life of the people centered around the ritual observances which they feel are essential to bring rain to the thirsty land

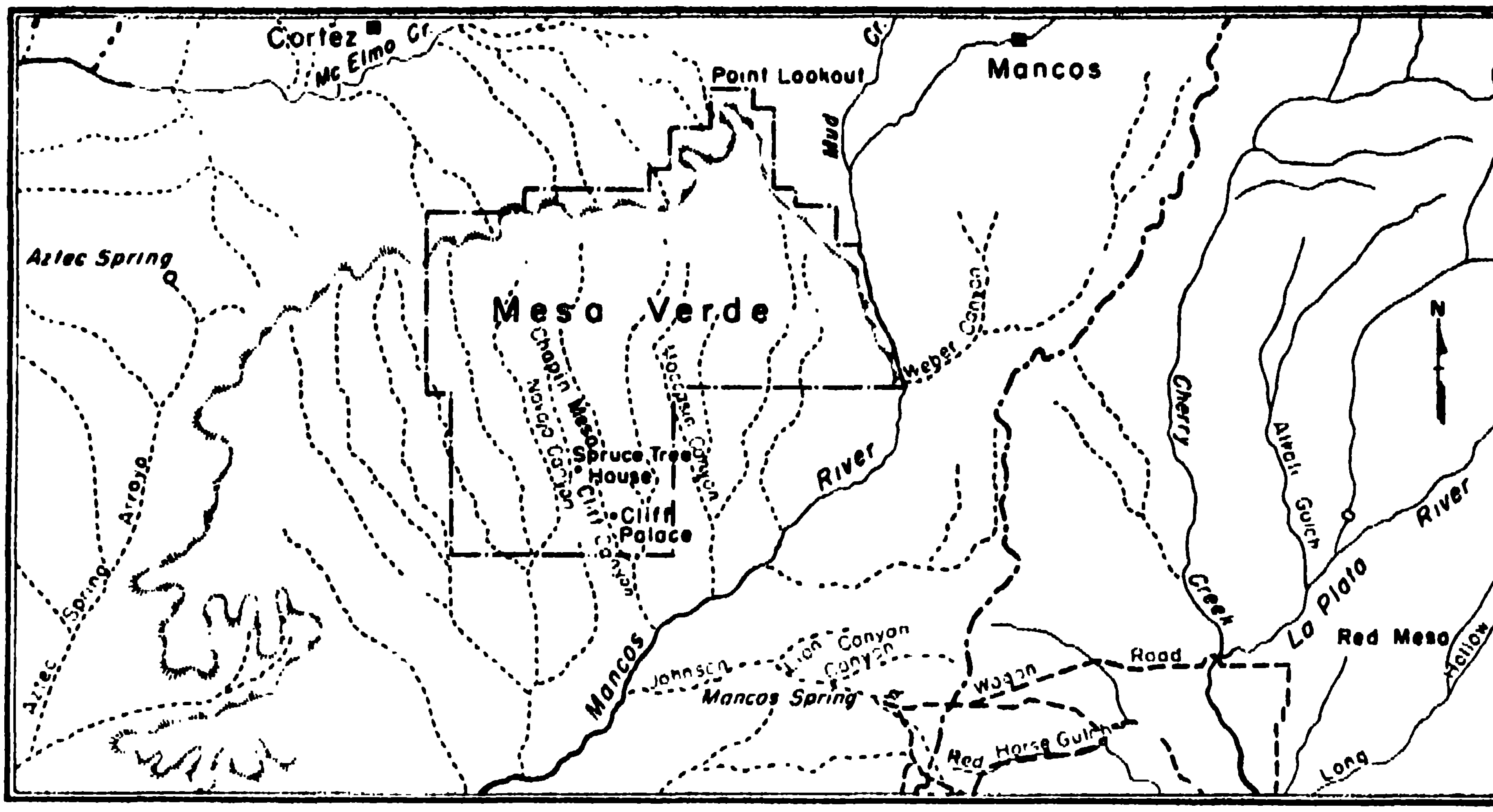


FIG. 2. SKETCH MAP OF MESA VERDE PLATEAU, SOUTHWEST COLORADO

—*Holzman*

FAR VIEW RUIN NEAR UPPER PART OF FLOOD WATER DITCH

—*Holzman*

CHECK DAMS ON WEST BRANCH OF SODA CANYON, MESA VERDE
PROBABLY USED FOR VILLAGE GARDENS.

and which mark as well each stage in the development of their greatest crop, the corn plant.

In the preliminary work so far carried out the writer has been aided by information from friends and associates in the Soil Conservation Service, by scientists and officials of the National Park Service, as well as by members of the staffs of the several Southwestern museums and interested specialists of the faculties of the Universities of Arizona and New Mexico.

When Spanish exploration of the Pueblo country started in 1540, the most important native settlements in the region were confined to the Rio Grande country, together with the Hopi and Zuni villages. Even there abandonment and resettlement of early sites had taken place on a large scale. One of the most important groups of Pueblo villages, that of the Mesa Verde Plateau, had been given up so long before the appearance of the Spaniards that no reference to it occurs in any of the Spanish narratives of exploration. Hence, one is certain that evidence of agriculture found there is quite unaffected by old world influence.

Flood Water Agriculture at Mesa Verde

A sketch map of the Mesa Verde Plateau, in southwestern Colorado, is shown in Fig. 2, together with the portion of the area included in the Mesa Verde National Park. The present-day visitor to the park approaches from the northerly side of the fan-shaped tableland, over the excellently laid out modern highway, instead of coming in over the trails from the Mancos River, as Richard Wetherill and Charley Mason did when hunting for cattle in December, 1888. As they searched for lost stock

Stewart

PRESENT STATE OF MUMMY LAKE

PRIMITIVE INDIAN FLOOD WATER RESERVOIR ON CHAPIN MESA, MESA VERDE.

—Holzman

CROSS SECTION OF UPPER PART OF INDIAN FLOOD WATER DITCH

NEAR FAR VIEW GROUP, MESA VERDE. JAMES A. LANCASTER IS IN THE FOREGROUND.

along Chapin Mesa they had the notable experience of finding the splendid ruined villages of Cliff Palace and Spruce Tree House in the same day. Their surprise could hardly have been greater had they found these two sites occupied by the early inhabitants. The impression made on almost every visitor who looks on these extensive towns for the first time is that of viewing something unreal. Even before the two sites were restored, both villages appeared to be astonishingly complete and ready to spring again into life and activity.

The modern road climbs up to the higher rim of the plateau, past striking remnants of the mesa top, segregated and left standing apart in early geologic time. On reaching the top of the divide it brings one near Park Point, where a sweeping view is obtained, showing the extent of the fan-shaped tableland, reaching some 15 miles east and west and 12 miles north and south. As the visitor comes down the highway along Chapin Mesa he reaches the Far View group of ruins which is near the upper end of an unusually complete unit of early flood water irrigation. The extent of this system on Chapin Mesa is indicated in Fig. 3, which shows a primitive flood water ditch that apparently supplied corn fields and check dam garden areas along the mesa top. The mapping was carried out by the Soil Conservation Area office, Farmington, New Mexico, during the past year.

The definite beginning of this flood water system is a little above Far View House and consists of a circular reservoir commonly known as Mummy Lake. This ancient reservoir has been mentioned ever since the first explorations on the mesa, but its possible connection with flood water irrigation was not recognized until James A. Lancaster of the park staff made a careful study of the area. Some indication was noted during the writer's field work, suggesting that feeding ditches possibly continued up the mesa above Mummy Lake. There is no present sign, however, of a more continuous source of supply than surface run-off from the upper portions of Chapin Mesa, where precipitation appears to be heavier with the increase in elevation.

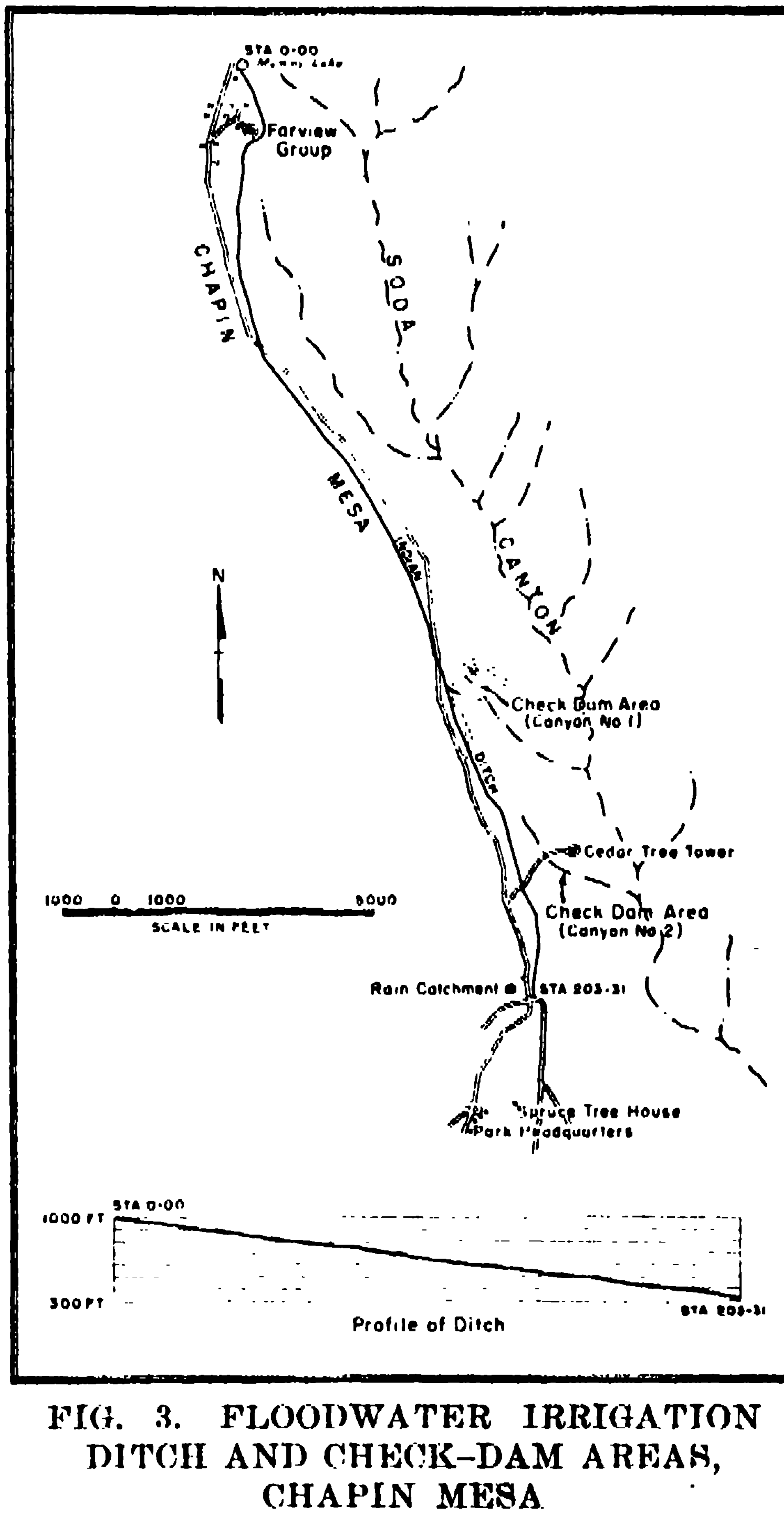


FIG. 3. FLOODWATER IRRIGATION DITCH AND CHECK-DAM AREAS, CHAPIN MESA

It is known that Mummy Lake was used by cattlemen for water storage for a few years following the discovery of the principal ruins. Examinations of the profile of the deposits in the bottom of Mummy Lake by R. J. Finley, conservation surveyor, and the writer,

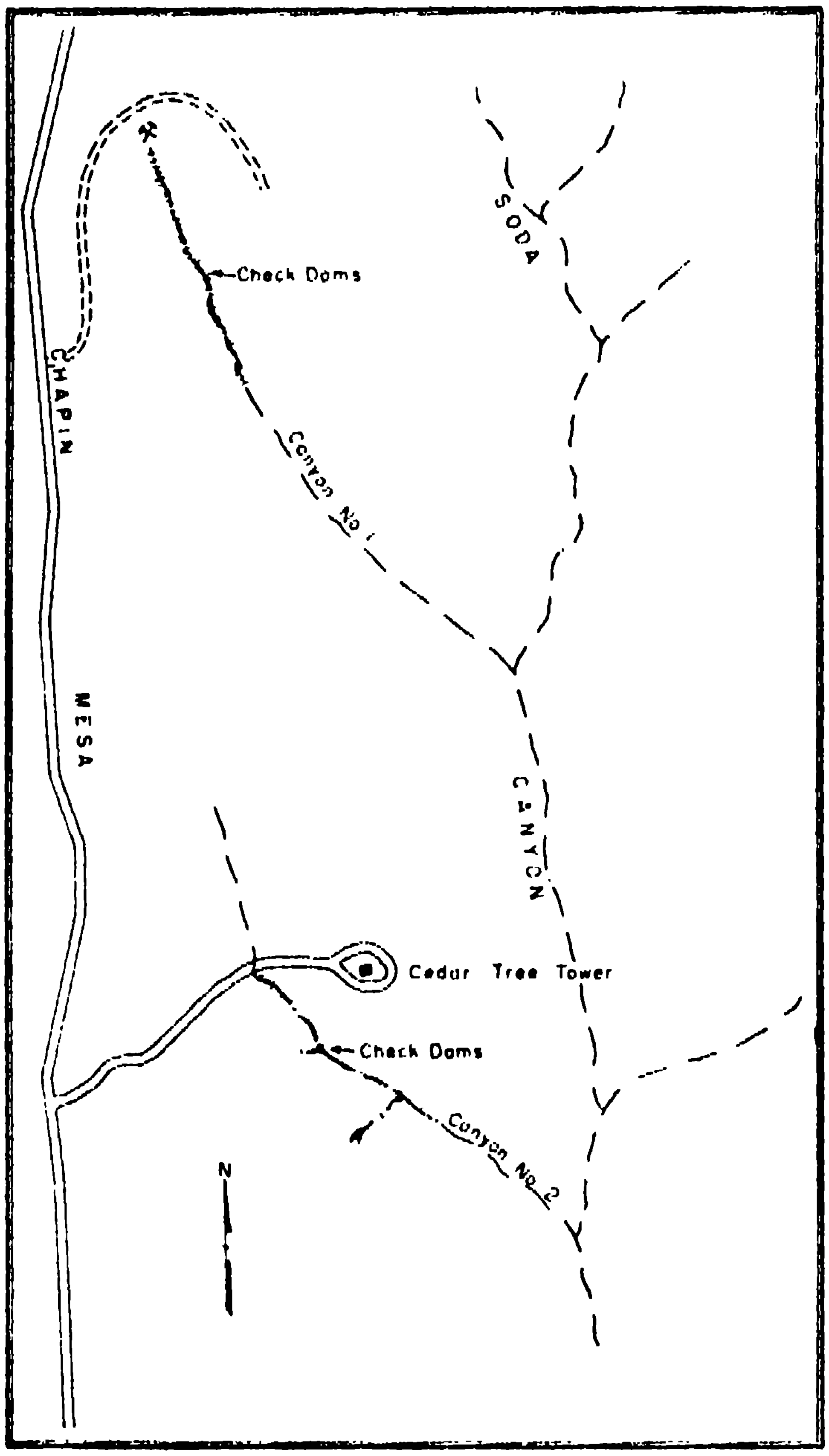


FIG. 4. CHECK–DAM AREAS ON TWO BRANCHES OF SODA CANYON

showed a deposition of stratified silt and sandy clay loam reaching to a depth of approximately 10 feet. This appears to be a far greater deposit than would ordinarily have developed from the run-off water on the mesa unless Mummy Lake had been used for water storage over a long period of years.

Along the ditch evidence was found at several points indicating where water might have been turned out on the corn fields. In a few places it is possible that additional flood water was also picked up. In some spots the bed of the ditch was stabilized with rock cross checks and the bank on the lower side was sometimes reinforced with stones. A typical cross section of the upper part of the ditch is shown in an accompanying view. The entire length of the flood water supply ditch from Mummy Lake to the lower check dam areas measures approximately four miles.

It is worthy of note that the cross section of the ditch is relatively broad and flat and is almost identical with the type of ditch outline developed by the Soil Conservation Service for terrace outlets and other vegetated waterways. Finley and the writer made a series of measurements of the cross section at somewhat over a dozen points along the ditch. These showed that the width of the ditch varied from a minimum of about 23 feet to a maximum of over 43 feet, with an average of 30 feet 6 inches. The depth varied from 6 inches to 18 inches, with an average of about 11 inches. Relatively little erosion had occurred in this type of flood water channel. This was probably due largely to the broad, shallow cross section which has tended to prevent concentration of flood water, with consequent cutting of a central channel.

At the present time, the land occupied by the ditch and that adjacent to it supports an open stand of piñon pine (*Pinus edulis* Engelm.), mixed with juniper (*Juniperis Utahensis*). Increment borings made in the larger piñon trees showed an age usually of from 140 to 155 years, with a maximum of 175 years. Since the piñon pine, according to Sudworth, has an age of only 100 to 225 years and no appreciable number of old stumps are visible, it is probable that the trees have gradually seeded in from land carrying trees adjacent to the flood water irrigated areas.

In the lower part of Fig. 3, it will be seen that the profile or grade of the ditch is remarkably uniform through its entire course, even though the ditch follows a

somewhat irregular line down the mesa. This would point to some definite plan or method of engineering to obtain this result over a distance of 4 miles and indicates skill of an exceptional type among these primitive cultivators. Had the ditch been run with only a slight fall, as was often the case with early Indian ditches examined by the writer in the Salt River Valley, it would have been easy to construct an excavation by having standing water follow the excavators. Where a steeper gradient was used, however, a more advanced technique was evidently required.

Two areas of garden check dams were located adjacent to the flood water ditch on separate branches of Soda Canyon. The general location of each group is shown in Fig. 3, and a larger scale mapping is presented in Fig. 4. The check dam type of village garden is a characteristic feature of the agriculture at Mesa Verde, and groups of these small garden plots are found close to many of the ruins upon the plateau, as on Wetherill Mesa near Kodak House, Long House and Jug House. Similar groups of check dams were examined on the mesa at the head of Moccasin Canyon. The probable use of these plots for village gardens has been recognized for many years by the Park Service staff at Mesa Verde. The individual check dam gardens vary widely in size. Some may be as small as 6 feet by 9 feet, while others are as wide as 35 to 45 feet, with a probable cultivable breadth of 10 to 15 feet to the base of the next check dam. The checks all have a definite type of construction, with the corner of the dam well toed in to the bank in order to stabilize the structure. They were, in most cases, built on rock ledges and originally contained about 3

—*Holzman*

SPRUCE TREE HOUSE AT MESA VERDE

NEAR LOWER END OF INDIAN FLOOD WATER DITCH, WITH A PROBABLE POPULATION OF 350 PEOPLE.

—Stewart

SQUARE TOWER HOUSE, MESA VERDE
DISTINGUISHED FOR ITS HANDSOME TOWER AND WELL-PRESERVED CEREMONIAL KIVAS.

to 4 feet of soil which would have been adequate to mature shallow-rooted crops such as beans, early corn, squash and pumpkins. Finley noted that the soil in the check dam areas, in most cases, was a rich, highly organic clay loam or fine sandy loam, which should have been adequate for excellent crop growth. His examinations indicated that the checks had been made and then repaired at a later date, as two types of deposited material were present in those found along Soda Canyon. The early builders exercised considerable judgment in the size of the material used for construction. Where the grade was unusually steep, large, heavy, flat rocks were employed, while small, flat boulders were used on the more level portions of each area. It is not surprising to find that portions of most of the checks have been washed out, but since no maintenance work has been done upon them for at least 640 years, it is remarkable that a large portion of many checks is still in place.

Examinations showed definite indications of probable water diversion from the flood water ditch onto both of the Soda Canyon check-dam areas. It is, therefore, clear that the flood water supply ditch would have played an important part in making good the deficiency of moisture on the lower part of the mesa when heavier precipitation occurred at higher elevations.

The best evidence which can be obtained as to the crops grown at Mesa Verde is furnished by the excavations of Fewkes at Spruce Tree House and Cliff Palace, in which he has recorded the materials found in food caches. The buried foods consisted of corn, beans, squash, pumpkin and gourds. Fewkes also found wooded planting sticks similar to those used by the present-day Hopi, at both locations on Mesa Verde. This makes it probable that agricultural meth-

ods similar to those of the Hopi and Zuni were followed in early plantings on the plateau. Balls of raw cotton yarn or wicking, as well as cotton string with feathers wound around them, have been reported from the ruins. More of these cotton materials have been reported from ruins south of the Mancos River than from those north of this point. Well-woven cotton cloth has also been found by Fewkes at both Spruce Tree House and Cliff Palace, but no caches of cotton seed have been reported.

The writer has discussed the possibility of growing cotton at Mesa Verde with several cotton specialists of the Department of Agriculture. Studies have been made by Dr. T. H. Kearney of native Hopi cotton, which is still grown for ceremonial purposes near the Hopi villages at the present day. The Hopi cotton has been found to have a shorter growing period than the usual agricultural varieties, and it is not impossible that an earlier maturing strain might have been isolated from Pueblo cotton varieties, by careful hand selection, choosing the plants which blossomed and matured earliest in the fall. A study of the frost-free period at Mesa Verde shows a notable variation in the date of the last killing frost during the last 16 years of available records. In two years it was as early as April 8, but in two other

—*Stewart*

CLIFF PALACE, THE MOST EXTENSIVE VILLAGE AT MESA VERDE

THE HOUSES AND KIVAS ARE SO COMPLETE THAT THE RUIN APPEARS READY FOR OCCUPANCY.

years it was as late as May 23 and 29. This indicates it would have been difficult for a cultivator to take advantage of the full frost-free period, which has ranged from 146 days in 1924 to 197 days in 1936. In view of the great variability in the frost-free season, it seems probable that the cotton fiber and cotton cloth reported by Fewkes were acquired by trade from neighbors to the south.

In addition to the length of the frost-free period at Mesa Verde, the amount and distribution of the rainfall is of prime importance. The annual precipitation for the 17 years of available records, at the Park Headquarters, has averaged 21 inches. This total is higher than that recorded at Cortez in the Montezuma Valley or for any of the stations in the Navajo country to the south. Durango is the only station in this general region with approximately an equal rainfall amounting to 19.8 inches for a 44-year period. Although the amount of water falling on the mesa in recent years is greater than at many other points in this part of the arid Southwest, the distribution of the rain is irregular during many years and in ten years out of seventeen has been deficient or entirely lacking during June. This is the month in which corn would probably be planted and points to a need for supplementary water during the early growth of crops. Although the deficient June precipitation constitutes a major agricultural risk there is some compensation from the fact that there has frequently been excellent rain during late July, August and September.

The best picture of rainfall variations in early times is probably obtained from the tree ring studies of Douglass[1] at Mesa Verde. He has shown that alternations of wet and dry weather occurred in the past, but a long period of drouth started

[1] A. E. Douglass, *Nat. Geog. Mag.*, 56: 737–770, 1929.

—*Stewart*

NAVAJO CORN FIELD NEAR CHAPIN MESA IN MESA VERDE PARK

WHERE A FAIR CROP WAS MATURED IN 1939, AFTER A DRY YEAR, USING INDIAN PLANTING METHODS.

about 1276 A.D. and continued until 1299 A.D. This abnormal condition apparently wiped out all food reserves of the early inhabitants and caused the complete abandonment of the plateau. In this connection it is important to remember that the small ears of corn found by Fewkes in the Cliff Palace and Spruce Tree House ruins may have been raised during the last drouth period and so may not represent the normal size of ears produced with adequate rainfall during the time of early settlement.

The studies made at Mesa Verde indicate an integrated system of agriculture on one portion of the plateau which shows an unusual organizing ability upon the part of the primitive cultivators. An excellent trail dating from early times is still in existence between the Far View group at the head of the ditch and Spruce Tree House near its lower end. It would have been extremely easy for a runner to have given warning to the residents below that flood water was beginning to come down from the upper mesa when rainfall occurred which produced run-off, in order that the cultivators might come out and assist in the distribution of the water to the corn fields and check dam areas. Such evidence of an organized layout of supply ditch, corn fields and check dam gardens would either point to the presence in this part of Mesa Verde of an unusually able group of primitive cultivators and engineers, or else may indicate a general pattern of agricultural development of a relatively high order for a primitive race upon the entire plateau. Further study will be necessary to determine which of these possibilities is applicable.

Water conservation was evidently the principal purpose of the Mummy Lake reservoir and flood water ditch system down Chapin Mesa. The choice of the ditch cross section, however, was extremely effective in avoiding excess wash-

—*Stewart*

GENTLY SLOPING WATER-RETAINING BOULDER DAMS

ON THE MESA NEAR PECK'S WASH, 2.8 MILES FROM PIMA, ARIZONA, USED FOR EARLY AGRICULTURE.

ing and channel cutting. In the check dam garden plot areas, which were partly located upon solid bed rock, there is considerable evidence that planned soil conservation to retain soil for the house gardens was as much the purpose as was water saving. The two types of practice blended together, and it is safe to say that the check dam gardens form one of the earliest groups of American soil and water conservation demonstrations which can be definitely stated to date back to 1300 A.D.

A study of the available records of precipitation indicates that in most years Mesa Verde has been better supplied with rainfall than other places to the west and south. This has amounted to about six and a half inches more moisture than has fallen at Cortez and approximately twice the average for Chaco Canyon and Aztec. The deficient precipitation of June is also one of the risks to which crops are exposed in many places of lower average rainfall. Hence, the excellent rains of late July, August and September have meant that corn was likely to mature on the plateau unless a major drouth occurred such as that which probably wiped out the early settlements. Recently a demonstration corn field has been planted each year by the Navajos at the park on an area which receives some local run-off and is located near Chapin Mesa. Corn crops have been matured even after relatively dry years, when planted by methods similar to those used by the Pueblo Indians.

The relatively favorable agricultural conditions found at Mesa Verde probably increased the risk which the early cliff dwellers had from attacks by their enemies during years of partial failure around them, and point to one reason for their making their homes in the cliff-side refuges.

—*Stewart*

PRINCIPAL RUIN AT CASA GRANDE, ARIZONA

PROTECTED BY A MODERN ROOF AGAINST WASHING BY RAIN. THE VILLAGE AT CASA GRANDE WAS THE CENTER OF A COMMUNITY OF EARLY IRRIGATORS.

—*Stewart*

VILLAGE OF WALPI, LOCATED ON FIRST MESA
ONE OF THE OLDEST OF THE HOPI COMMUNITIES.

—*Stewart*

FLOOD WATER FIELD, HOPI, FIRST MESA
RECEIVING RUN-OFF FROM UPPER LAND.

—*Stewart*

CORN DRYING IN THE YARD OF THE GOVERNOR'S HOUSE AT WALPI
PART OF THE SHORT HARVEST OF 1939.

PUEBLO AGRICULTURE IN THE UPPER RIO GRANDE AND GILA RIVER VALLEYS

A survey was made of present-day agricultural methods in the villages along the Rio Grande from Acoma to Taos. Planting, cutivation and irrigation have, in most cases, been greatly affected by the irrigated agriculture learned from the Spaniards so that it is difficult to find many examples of Indian cultivators who follow the old Pueblo practices unchanged as they may often be seen in the Zuni and Hopi country. This is not surprising when we read in the account of Oñate's settlers in 1598 that the expedition reached Santo Domingo on July 7, and on August 11 work was started on an irrigation ditch with 1,500 Indians helping.

Examination of the fascinating ruins of Puye and El Rito de Los Frijoles showed little evidence of early agricultural use that is definitely related to pre-Spanish cultivation around either site.

Along the Gila River a number of interesting examples of water detention structures were noted. One of these, located on the bench above Peck's Wash some 2.8 miles from Pima, Arizona, was examined intensively by John Cole, Soil Conservation Service, and the writer. On this area somewhat over 25 acres is laid out, with simple water detention boulder dams forming a complete spreading system. In the upper portion of the tract the detention structures were roughly rectangular in shape, varying in size from 8 by 10 feet up to 24 by 30 feet. At the present time there is no evident source of water for this group of farm plots, though it appears probable that the entire course of the surface drainage has been changed by an early washout. In the lower part of the area a definite system

—Stewart

WATER DETENTION BOULDER CHECKS AT SHUCKING RANCH
NORTH OF SELIGMAN, ARIZONA.

of terraces had been laid out on a grade of 2½ to 3½ per cent. The terraces ranged from 14 to 18 feet in width and extended from 180 to 225 feet long.

Deadman's Gulch and adjacent canyons across the Gila on Graham Mountain were found to contain a different type of garden site. Here a primitive style of terrace had been built, largely by clearing the land of loose boulders and piling them on the outer edge of the terrace bank. In places simple boulder water detention dams had been put across the stream to check the force of the flow. Portions of this area, examined by Dr. Emil Haury, were dated for the probable period of occupancy, by pottery shards, at A.D. 1200–1400.

Another use of boulder detention dams was studied in the Cañada del Oro, about 17 miles from Tucson, Arizona. Here single lines of larger boulders have been used for water detention on a tract of over 30 acres. In many cases the boulder dams were spread in a series of checks across a field at intervals of 10 to 25 feet, between the detention checks. The channels which would have carried water from one check to the next lower structure were often stabilized with boulder checks to prevent washing. The layout of the checks on this tract, as well as on the extensive tract at Peck's Wash, suggests that the primitive irrigators would have needed to get out on their fields during times of run-off to guide the water from one series of checks to the next and alter the supporting boulder walls as conditions showed were necessary to secure an even distribution of water.

In the lower part of the Gila River Valley, near the ruins of Casa Grande, and in the Salt River Valley adjacent to Phoenix, some remnants of the most ex-

—Stewart

GRAND CANYON FROM DESERT VIEW ON THE SOUTH RIM

ACROSS THE NORTH RIM, WATER DETENTION CHECKS SIMILAR TO THOSE FOUND AT THE SHUCKING RANCH HAVE BEEN REPORTED.

—Stewart

GRAND CANYON FROM MORAN POINT, LOOKING TOWARD NORTH RIM

WHERE PRIMITIVE WATER DETENTION CHECKS HAVE BEEN REPORTED.

tensive primitive irrigation systems in North America can still be found. These areas of early Pueblo culture, known as the country of the Hokokam, have been variously estimated to have embraced from 100,000 to 250,000 acres of irrigated land. In the development of modern systems of irrigation most of the early ditches have been plowed up and obliterated. The writer devoted some study to portions of the early Indian Salt River system which has been mapped by O. A. Turney. The parts of the ditches examined lay north of Phoenix, just below Pueblo Grande, where at least four separate ditches were diverted from the river in the direction of the former Indian settlement known as Casa Buena and La Ciudad. The distinctive feature about these canals was the fact that they were dug by hand and had a relatively flat gradient. Portions of the banks gave some evidence of possibly being lined with clay which may have been hardened by fire before water was used in them continuously. Since all the Hokokam settlements were abandoned before Spanish settlement, it is impossible to say whether this irrigation system was used to supply flood water to land where the water would be impounded and allowed to soak in, or whether irrigation was applied continuously during the growth of the corn crop. The principal interest of this paper is in the methods used under the more rigorous conditions found in the more arid portions of the Pueblo country, hence no attempt will be made to treat of the evidence of agricultural practice with a relatively assured water supply.

In the northern part of the Salt River Valley, near Cave Creek, a striking example of a self-contained agricultural community was studied. This was the so-called Fort Mountain site illustrated in Fig. 5. The main portion of the village was located north of the large hill. On the top of this eminence, rising some 500 feet above the surrounding country, was a refuge fort with walls 4 to 5 feet high and some 4 feet thick, made from piled-up boulders. A relatively wide flat diversion ditch for flood water ran from the adjacent creek to a tract of some 30 to 40 acres of corn land which would have been adequate for village needs. In addition, a number of boulder, walled, house garden patches were located on the south of the main hill. By means of these

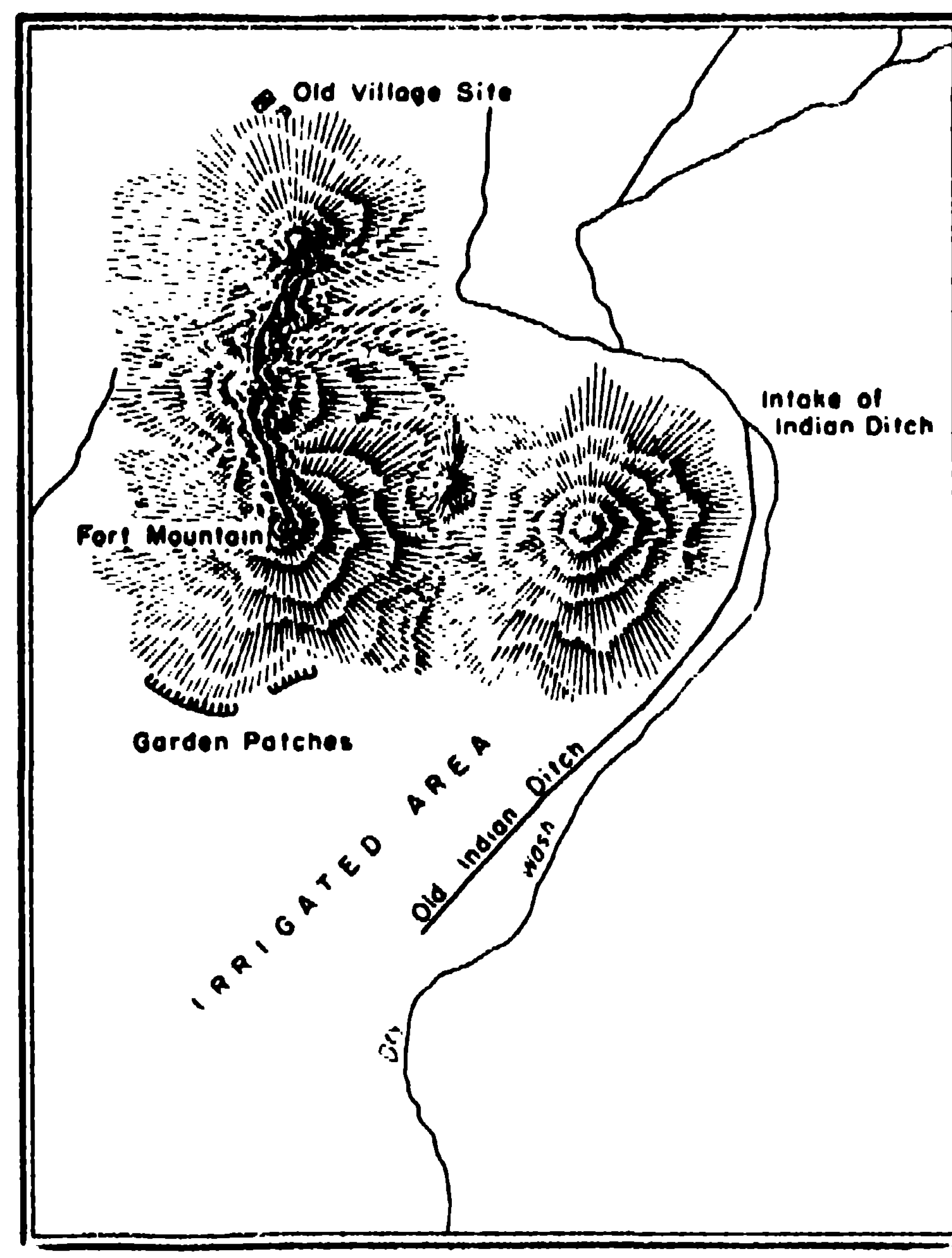


FIG. 5. MAP OF FORT MOUNTAIN SITE NEAR CAVE CREEK DAM, ARIZONA

check dams, flash run-off could have been retained so that crops of beans, squash, early corn or cotton could have been grown. At first glance it appeared that the village should have been placed nearer to the agricultural area, but it was later discovered that the best trail up to the fort lay on the village side of the hill. Upon reaching the fort, the entire cultivated land, as well as the village, could be easily watched so that

human foes or destructive animals could be detected. Pottery shards dated the occupancy of the village at from 1000 to 1200 A.D.

EARLY SITES FROM PHOENIX TO THE GRAND CANYON

A series of primitive village locations extending north from Phoenix, including sites on New River, Upper and Lower Alkali Wash, Agua Fria Canyon, Bishop Creek, Hackberry Wash, five sites in Lonesome Valley, northeast of Prescott, one large area near King's Ranch Pueblo and a group of ruins north of Seligman were all studied and evidences of early agriculture were found. In the majority of these village communities a group of small garden plots partly terraced on a gentle slope, with stabilizing rows of boulders at the outer edge, were found close to the village. The main dependence for such gardens was upon local run-off. In two cases, however, entire fields at King's Ranch Pueblo and Shucking Ranch north of Seligman were laid out with water detention boulder checks to insure success of the corn crop.

Preliminary examinations at the Grand Canyon National Park indicated that agriculture was practiced on the plateau adjacent to the north rim, while cotton seed found by the park staff in small ruins adjacent to Bright Angel Trail, points to the growth of this plant in gardens in the lower parts of the canyon. It is hoped to make more detailed studies in both locations at a later date.

THE HEAT OF THE SUN

AFTER stating the probability that, if sunlight was ready, the earth was ready both for vegetable and animal life within a century, or at least a few centuries, after the consolidation of the earth's surface, Lord Kelvin inquires whether the sun was ready, and replies:[1] "The well-founded dynamical theory of the sun's heat carefully worked out and discussed by Helmholtz, Newcomb and myself, says NO if the consolidation of the earth took place as long (ago) as 50 million years; . . .

Here is an unqualified assumption of the completeness of the Helmholtzian theory of the sun's heat and of the correctness of deductions drawn from it in relation to the past life of the sun. There is the further assumption, by implication, that no other essential factors entered into the problem. Are these assumptions beyond legitimate question? In the first place, without questioning its *correctness*, is it safe to assume that the Helmholtzian hypothesis of the heat of the sun is a *complete* theory? Is present knowledge relative to the behavior of matter under such extraordinary conditions as obtain in the interior of the sun sufficiently exhaustive to warrant the assertion that no unrecognized sources of heat reside there? What the internal constitution of the atoms may be is yet an open question. It is not improbable that they are complex organizations and the seats of enormous energies. Certainly, no careful chemist would affirm either that the atoms are really elementary or that there may not be locked up in them energies of the first order of magnitude. No cautious chemist would probably venture to assert that the component atomecules, to use a convenient phrase, may not have energies of rotation, revolution, position and be otherwise comparable in kind and proportion to those of a planetary system. Nor would he probably feel prepared to affirm or deny that the extraordinary conditions which reside in the center of the sun may not set free a portion of this energy. The Helmholtzian theory takes no cognizance of latent and occluded energies of an atomic or ultra-atomic nature. A ton of ice and a ton of water at a like distance from the center of the system are accounted equivalents, though they differ notably in the total sum of their energies. The familiar latent and chemical energies are, to be sure, negligible quantities compared with the enormous resources that reside in gravitation. But is it quite safe to assume that this is true of the unknown energies wrapped up in the internal constitution of the atoms? Are we quite sure we have yet probed the bottom of the sources of energy and are able to measure even roughly its sum-total?—*Thomas Chrowder Chamberlin, in a reply published in "Science" on June 30 and July 7, 1899, to Lord Kelvin's address at the Victoria Institute in 1897 on "The Age of the Earth as an Abode Fitted for Life," published in "Science" May 12 and May 19, 1899.*

[1] *Science*, May 19, 1899, p. 711.

ANTIDOTES FOR SUPERSTITIONS CONCERNING HUMAN HEREDITY

By Dr. KNIGHT DUNLAP
PROFESSOR OF PSYCHOLOGY, UNIVERSITY OF CALIFORNIA AT LOS ANGELES

SOME thirty years ago the Kallikak family was boosted into an unfavorable notoriety, and shortly became a great asset to propagandists for eugenical sterilization and other nostrums. Even in books written by psychologists who ought to know better, the Kallikaks skulk in the corners of the pages, and leap out upon unwary students.

The fame of the family began with an anecdote perpetrated with incredible innocence by an eminent expert on "intelligence," and repeated with astonishing solemnity by many after him. The anecdote concerned the unblest union of a Revolutionary soldier with a feeble-minded girl, from which sprang a long line of descendants who were feeble-minded and prone to epilepsy, alcoholism, prostitution and what have you. I have often told this story to classes, and waited to see how many students would raise the obvious question: How do you know the girl was feeble-minded? Did anybody test her and assign an I.Q.? What is the evidence? Of course, there is no evidence. The promoter of the legend inferred that the girl was feeble-minded because she had feeble-minded descendants. Then, from the assumption of her feeble-mindedness he inferred the fatal heredity of amentia. This procedure, of assuming the conclusion in the premises from which it is presumably drawn, is called by the logicians, "Begging the question."

The Kallikak phantasy has been laughed out of psychology, along with the even more appalling legends of the Nams and the Jukes; but the theories involved in them still linger in popular superstitions, endorsed by many writers of supposedly scientific books, along with other popular beliefs about heredity, and do definite damage to young persons who take the theories seriously. Many of these young persons fear to marry, lest their children should be feeble-minded, since they think there have been feeble-minded persons in their families in past generations.

The fear of hereditary mental disease, played up by eugenicists and other fear propagandists, has driven many young men and young women into maladjustments, and even into suicide or neuroses. Almost every psychologist is familiar with these cases, some of which come to him for help. The great majority, however, do not know that help is possible.

Dr. Abraham Myerson, in his book reporting the findings of the committee of which he was chairman, has done excellent work in disemboweling the alleged evidence for the fatal heredity of mental diseases, but relatively few of the victims of the superstition will read the book, and those who do are apt to be misled by the summary of conclusions, which is not based on the analysis of the book itself, but appears to be a compromise between the real showings and the prejudices of committee members. Meanwhile, the propaganda for a stupid type of heredity for mental disorders goes on in popular and professional journals.

Psychologists find no difficulty in resolving the difficulties of neurotic or perturbed youngsters who seek their advice. For the benefit of the layman, it may be worth while to summarize the psychologist's procedure. In the first place, he points out that nothing is really known about human heredity, except that certain traits, such as red hair, haemophilia and Presbyterianism, "run in families." That for most traits, we do not know how they "run," the traits for which the

principles of inheritance are known, even vaguely, being very few. And that hasty inferences from traits of fruit-flies and potatoes to human traits has not been useful.

The psychologist, in the second place, will point out that the scare-data which has been assembled to prove the fatal heredity of mental diseases and of feeble-mindedness, has been gathered by the too-familiar method of selecting the data which agrees with one's theory while ignoring cases which would not support it. In regard to feeble-mindedness in particular, he points out that some of the data which impresses the public most was gathered by untrained persons, who were not able to tell whether an individual is feeble-minded or not.

In the third place, he points out that principles, or "laws" of inheritance for any trait, while they may possibly be developed for some simple physical traits, could hardly be expected for complex conditions, such as epilepsy and feeble-mindedness, until we know what the immediate causes of these conditions are; and that at present we do not know how many different abnormal conditions are lumped together in these waste-basket classes. It is useful, moreover, to point out that the mental disorders of which the causes are definitely known, namely, the organic psychoses, are not included in the group to which a fatal hereditary nature is ascribed by the pseudo-geneticists, who confine their scare propaganda to the disorders of unknown nature, such as feeble-mindedness, idiopathic epilepsy and the disorders in the other waste-basket which are called "dementia praecox" or, in flossier and more misleading terminology, "schizophrenia."

In these ways the psychologist emphasizes the fact that, for a person who discerns an occasional nut or two on his family tree, the chances that he will have a nut for a child are, *so far as is now known,* no greater than for the person who doesn't happen to find any nuts on his tree. For the young man who is convinced, on the basis of popular heredity doctrines, that he is going insane, the relieving conclusion is as obvious.

The frightened young persons of whom I have been speaking are, of course, not themselves feeble-minded, or mentally "diseased," although some of them are temporally neurotic because of their fear of the fell effects of heredity. The feeble-minded and the deranged would not be advised to marry for practical reasons not connected with the superstitions concerning heredity; the neurotic are advised to do something about their neuroses before planning to marry. In every case, the patient is assured that the problems of heredity are of great importance, but he is reassured that the scientific problems are far removed from the superstitions which are troubling him.

In some cases of perturbation or neurosis induced by superstition masquerading as science, I have found it well to go a little further, and discuss superstitions concerning the heredity of traits not connected with the particular problems of the patients. Among these traits, which in many cases are not causes of worry, are eye-color, color-blindness and deafness. In some cases, of course, superstitions regarding these are important sources of perturbation.

The eye-color doctrine is familiar. There are two classes of eyes, often called "blue" and "brown," other colorations being ignored. The ignoring of green, red and violet colorations, however, is sometimes a little strong for the pseudo-geneticist to swallow, so he classes eyes simply as "light" and "dark." The inheritance of the two colors is put on a simple Mendelian basis. Blue is recessive, brown is dominant. As a consequence, it is not lawful, in the Mendelian sense, for the child of two blue-eyed parents to have brown eyes. The number of brown-eyed children who, through the taunts of companions or their own imbibing of pseudo-science, have been made

miserable by the suspicion that they are illegitimate, or what is often as bad, adopted children, is larger than the layman might suppose.

The eye-color superstition is of origin somewhat less ancient than the superstition concerning feeble-mindedness. Put forward in a simpler form at first, with the rising tide of Mendelianism it received its present shape, and was so generally accepted that only recently has it begun to be eliminated from text-books. Genetic studies of eye-color inheritance were made without the careful examination of any eyes. Of course, the data were probably selected, for even on casual examination of eyes many disturbing cases appear; but these can be treated as "anomalies." Actual study of eyes shows at once that eye-color, in a mixed population, such as that of the United States or European countries, is not an "all-or-none" matter, but the colorations of the iris are mosaic patterns involving usually more than two colors. Eyes classified as "blue" on casual examination often show, when really examined, greater area of brown in the iris than of blue. The brown-eyed child who is worried about his parentage can resolve his doubts easily by examining the eyes of his putative parents with a good reading glass in good daylight. This procedure, one might suspect, would be unfortunate if the child were really adopted or his mother had been indiscreet. There is no reason for concern here. Eyes are mixed so generally that the chances that the brown-eyed child will not find some brown areas in the eyes of his putative parents are so small as to be negligible.

Superstitions concerning inheritance of color-blindness seldom produce neuroses. They are illuminating, however, in conjunction with the more deadly superstitions. The sex-linked color-blindness, described by pseudo-geneticists usually as an all-or-none trait, is most interesting; but psychologists have not been able to discover this sort of color-blindness. Nature, or the Creator, seems to have been unable to supply what the theorists need. The color-blindness we know, is a matter of great complexity of variation, shading from slight color-weakness to extreme protanopia and deuteranopia with other forms not as yet fully investigated. In some cases, it "runs in families"; sometimes, indeed, appearing to crop out in grandfather and grandson, skipping the intermediate mother. In other cases, it appears to crop out in grandmother and granddaughter, skipping the intermediate father. It appears, too, in father and son and mother and daughter, as well as in father and daughter and mother and son. The apparent "skips," moreover, can not be taken as certain in all reported cases, for the popular tests for color-blindness are highly unreliable, and in many cases only the persons under suspicion have been tested. The popular theory of the innate nature of the defect has been somewhat demoralized by the discovery of cases which are normal in color vision in early adolescence and typical deuteranopes a year or two later. From case histories of persons who "suddenly" discover, in the late teens, or later, that they are color-blind, we have reason to suspect that there are many cases of this kind. As for the causes of color-blindness, while we may suspect that in all cases it has a toxic or other chemical basis, as it certainly has in some cases, we are still lacking in knowledge; but we would, to-day, hesitate to say that it is incurable.

Investigations into the heredity of traits concerning which the investigator is uninformed, and which he would not know how to identify, are the outstanding sources of misinformation and support of superstitions regarding color-blindness, eye-color and feeble-mindedness. It is not without interest that the one field of heredity study in which the investigator is expected, first of all, to be able to diagnose the trait he studies, and to be well grounded in regard to it,

is the field of cancer; and that it is in this field that jejune conclusions are least conspicuous.

There is one more doctrine of pseudogenetics which, although exploded so far as science is concerned, is still popular and is still a source of perturbation and unhappiness, although, so far as I know, not a cause of neuroses or suicides. This is the doctrine that a person who is congenitally deaf is especially apt to procreate deaf children; and that the mating of two congenitally deaf persons is almost certain to result in deaf children, if any.

To a person worried lest his defect of hearing would be transmitted to his offspring, and hesitating to marry on that account, it is necessary to explain that cases of actual congenital deafness are few, and that there is only one type of deafness which is "hereditary," in the popular sense of the term, and that form, in which cochlea fails to develop, is rare. If there is a "hereditary" disposition towards contracting measles, scarlet fever, diphtheria, colds in the head and the other actual causes of deafness, that is another matter. The selected cases in which deafness "runs in the family" are no more significant than the cases of vegetarianism or poverty, which also "run in families."

The problem of deafness and its inheritance furnishes also an approach to the method of clearing up the difficulties of persons who have become impressed by the studies in which there has been an attempt to get at the "hereditary" factor in intelligence by correlating the intelligence of children with that of their parents through a simplistic use of intelligence scores. The "intelligence" which intelligence tests measure is, of course, not the same as the "intelligence" which is supposed to be inherited; and an inference from the first to the second can be made only on the basis of a vastly greater fund of information than the intelligence test scores supply. Aside from this, however, there is the fact that a trait which superficially appears to be "inherited" in a simple way may be a resultant of more fundamental traits, which, indeed, are inherited, but in a complex way. Thus, deafness may be a result of one of a number of different causes; such as scarlet fever, "colds" invading the middle ear, and so on. There may possibly be "inherited" susceptibility to one or another of these diseases, and so, indirectly, deafness may be "hereditary." Or, there may be "inherited" tendencies on the part of parents to neglect these diseases in children. The whole matter, however, is put on a different basis if we look at it from this point of view.

That feeble-mindedness in different individuals has different causes is entirely possible. Some of these causes may be hereditary in the way in which eye-color is (whatever that way may be). The heredity of others may be like the heredity of Presbyterianism. Until we know something of the approximate causes of feeble-mindedness, worrying about its mode of inheritance is fruitless.

Some of the traits, defects and diseases which 60 years ago were agreed to be "inherited" in the popular sense of the term have to-day dropped out of the picture. Thus, Darwin said in 1876: "Striking instances have been recorded of epilepsy, asthma, stone in the bladder, cancer, profuse bleeding from the slightest injuries, of the mother not giving milk, and of bad parturition being inherited."[1] To-day, haemophilia is admitted to be transmitted in families in a rather simple way; epilepsy is believed by some to be similarly "inherited"; the verdict on cancer is "not proven"; but "consumption" is no longer listed, because the primary cause of tuberculosis has been found. It is entertaining to note that Darwin quotes Dr. Garrod as saying that 50 per cent. of the cases of gout observed in hospital practice are "inherited." When the causes of traits,

[1] "Animals and Plants under Domestication," Chapter 12, 451–2.

defects and disorders are discovered talk about the "inheritance," as simple entities, of most of them, ceases abruptly. The real problem of heredity is not done away with, however, but is revealed as so complex that its principles have little in common with the popular doctrines handed down from the past.

The retailing of case histories is boring and unimpressive, but one case recently in my hands is so illustrative and so entertaining that it merits description. A college girl came to me for advice as to the method of committing suicide which would be least distressing to her family. She did not want advice as to whether or not to kill herself; she had decided that point. This was probably an overstatement, but that was her story.

In applying the routine technique for would-be suicides, I told her, of course, that suicide is often a good thing, but that the persons contemplating it are usually in no mental condition to make the decision, but need expert and disinterested advice. That, if her reasons for suicide were good, as they might be, I could indeed help her select an adequate method. She was reluctant to give her reasons, but finally came through. She was, she said, developing manic-depressive insanity. Her condition was becoming worse, and would, obviously, in the course of time be a great cause of shame and other trouble to her family, from whom, so far, she had concealed the facts. So, it was clear that she should commit suicide in the least flagrant way, before her mental condition should become too evident to be concealed.

On questioning her as to the evidences for her manic-depressive condition, I found that she had earlier taken a widely used test, which may conveniently here be classed as a "personality test," the results of which showed that she was of a manic-depressive type. I should say that the test was taken before entering the university, for we do not administer such tests except for illustrative purposes, with full explanation that the results are not to be taken seriously.

From this start in fear, the girl had commenced to read up on manic-depressive insanity, and, since she had not had a protective course in abnormal psychology, she discovered that she had the symptoms, as might be expected. From her reading also, she found that the disease is hereditary; and she found in her family tree one or two cases of what she *believed* was mental disease. In her perturbation, her symptoms of course became worse, and so the stage was set for suicide. Having courage enough, and self-sacrifice enough, to face suicide, she had not developed a serious neurosis.

It was not difficult to convince the patient that the test which started her into trouble was silly and that the doctrine of the inheritance of mental disorder, as she had learned it, was a myth; that her chances of going insane were no better than my own, or those of seven thousand of her fellow students. This treatment was effective. If the girl had been psychoanalyzed, or advised by an inexpert "psychologist," her chances would have been small for readjustment, if I may judge by other cases.

In summary and conclusion, I must insist that at the present time one of the major duties of psychologists, in the service of society, is to combat the popular superstitions about human heredity; to point out that while all human traits, without exception, are hereditary in the modern scientific sense of the term, we know nothing, as yet, about the modes or details of inheritance of important traits. It is our duty, further, to explain in detail the complete lack of scientific foundation for the popular theories, which, unfortunately, are still endorsed by some text-books. In this way, we can assist the prophylaxis against the most damaging of the superstitions.

MILESTONES IN METEOROLOGY

By WILLIAM HOLMES WENSTROM

MAJOR, U. S. ARMY (RTD.); FORMERLY WEATHER OFFICER WITH THE U. S. AIR CORPS

I

THE beginnings of meteorology, like the beginnings of most science and art, go back to the enlightened men who talked and walked and thought in the ever-varying alternations of warm sun and sea change that bathed the golden isles of Greece. Many of their thoughts in those early days were wide of the mark; but some have come down to us, and stand to-day as valid as they ever seemed of old. The Greeks made regular weather observations of a sort, principally of wind direction, as early as the fifth century before Christ. They introduced the eight cardinal wind points that are still used to-day—northeast, east, southeast, south, southwest, west, northwest and north. In the fifth century before Christ, also, Anaximander of Ionia defined the wind as "a flowing of air," which simple statement has never been improved upon since.

About 350 B.C. Aristotle, greatest philosopher of the ancient world, published four books under the general title "Meteorologica," meaning "the things above," and including phenomena astronomical as well as atmospherical. From the Greek word for "high in the air," also, grew our present name for the science of weather and climate—"meteorology." But if I may digress for a moment, "me-te-or-o-lo-gy" is, it seems to me, a clumsy word to spell and pronounce (to say nothing of that linguistic monstrosity "me-te-or-o-lo-gi-cal"), and somewhat too connected with meteors in the minds of laymen. If the inertia of long-continued and wide-spread usage could be overcome, it might be replaced by some more suitable term such as "aerology" or "atmology."

In Aristotle's treatise, at any rate, about one third of which was devoted to the science of the atmosphere, many weather questions were considered—the formation of fog and clouds, dew and frost, rain and snow and hail, theories of winds, thunderstorms and whirlwinds. The whole work was marked more by powerful imagination than by scientific method. Yet it was the earliest comprehensive work on meteorology, and remained for fifteen centuries the best. Theophrastus, one of Aristotle's disciples, also wrote a treatise on wind and weather which included some weather omens not unlike those that find credence to-day.

In ancient times life was leisurely and new developments came slowly. Rain, always vital to husbandry and farming, was the first weather element to be accurately measured. (Such measurement requires, indeed, nothing more complicated than an open bucket and a ruler.) As early as the first century A.D., rainfall measurements were made in Palestine, and the resulting rainfall records were preserved among the Jewish religious writings. Much later, by 1450, rain gauges were in use by the Koreans of China. But in the middle ages the frontiers of weather knowledge were already widening in another direction. During the eleventh century some Arabian astronomers, watching sunrise and sunset in the clear air of the Eastern desert, made the first rough estimate of the height of the upper atmosphere. They deduced from the duration of twilight that the earth's air extends in appreciable density to heights around fifty miles, and later experiments have confirmed their findings.

II

If meteorology may be said to have dawned in ancient Greece, its sun really rose in the sixteenth-century Tuscany of the Medicis. For weather work began to assume some dignity as an independent science when quantitative measurements of its several elements became possible; that is, when accurate weather-measuring instruments appeared. The first of these (aside from the rain gauge), and one of the most important, was the thermometer. Back in the third century, Philo of Byzantium and Hero of Alexandria had devised some primitive thermoscopes. The instruments themselves had probably no great value; but one of Hero's writings came, centuries later, to the attention of the first great experimental scientist—Galileo Galilei. He and his associates were to make northern Italy the cradle of instrumental meteorology and instrumental physics.

In 1592 Galileo, then at the University of Padua, constructed the first practical thermometer. Bearing small resemblance to the modern instrument, it consisted of a large bulb filled with air which, by its expansion when heated, forced downward the water level in a glass tube. Later, Galileo is thought to have devised, in essence, the modern thermometer—a small glass bulb of liquid free to expand into a sealed capillary tube. (The liquid was alcohol, still used in many modern instruments.) Thermometers of this type, at any rate, were used around 1640 by Ferdinand II, Grand Duke of Tuscany. Around 1720, Gabriel Daniel Fahrenheit started using mercury as a thermometer liquid, and devised the Fahrenheit scale that is still in ordinary use among all the English-speaking peoples. And about 1742, in Sweden, Anders Celsius devised the centigrade scale that is in universal scientific use to-day.

In 1640 also, the same Ferdinand II of Tuscany, one of the most enlightened of the later Medicis, entered the march of knowledge by ordering that a deep well be dug near Florence. Such an ordinary action might at first glance have been thought free from future scientific implications; yet it was found, to the surprise of all, that water would not rise in the well pipe, even when the air was drawn out of it, to a height greater than about 32 feet. Galileo, consulted near the end of his life's labors, judged that "nature's abhorrence of a vacuum," until then thought absolute, appeared to have limits. Before his death he suggested that liquids of different densities should rise to different heights in an evacuated tube, and passed the problem on to his pupil, Evangelista Torricelli.

Torricelli put the experiment on a more convenient scale by adopting mercury, the heaviest of all liquids, which rose about 30 inches in an evacuated tube. He then concluded that, in the words of Millikan and Gale, "the rise of liquids in exhausted tubes is due to an outside pressure exerted by the atmosphere on the surface of the liquid, and not to any mysterious sucking power created by the vacuum." Torricelli proved this by placing his whole barometer in a bell jar and pumping out the air, whereupon the mercury column sank in the barometer tube. Torricelli's barometer, unchanged in general principle though considerably refined in form, is used for all accurate pressure measurements to-day.

Barometry now moved by leaps and bounds. In France, Blaise Pascal reasoned that air pressure, like pressure in other fluids, should diminish as one goes higher in the atmosphere. Lacking a mountain on which to try the experiment, he wrote his brother-in-law Perrier in the south of France. In 1648 Perrier carried a barometer up a sizeable mountain (Puy de Dome) and was "ravished with admiration and astonishment" when he found

the mercury column sinking in the tube. The surveying aneroid and the airplane altimeter were now possible. In addition, the barometer was used to indicate daily small changes in atmospheric pressure, which before long came to be associated with weather changes; high pressure vaguely foretelling fair weather, and low pressure, foul.

The barometer and thermometer soon became, and still remain, the most important instruments in meteorology, but other developments followed fast. In 1653, that same Grand Duke of Tuscany, incidentally, whose well had started the whole barometer sequence, established several weather observing stations throughout northern Italy—the first weather network ever projected and the germ of modern weather-reporting services—and sought to establish also an international chain of stations.

Somewhere around 1667 men devised the earliest type of anemometer, giving the first numerical measure of wind strength; the device was merely a rectangular plate hung by one end so that increasing wind pushed it out to an increasing angle from the vertical. Rotating anemometers came into use by about 1724, and the instrument was further improved some fifty years later by the Swiss geologist, meteorologist and alpinist, Horace Benedict de Saussure. Saussure also pioneered much of the early work in moisture measurement; and he invented the hair hygrometer, which indicates the relative moisture of the air in simple and direct fashion by virtue of the fact that a strand of hair expands when it is moist, contracts when it is dry.

III

The great trade winds of the tropics had been known and used for centuries before any one sought rationally to explain them in the light of known facts. In 1686, Edmund Halley, soon after calculating the orbit and predicting the return of his seventy-year comet, published in England a paper entitled, "An Historical Account of Trade Winds and Monsoons Observable in the Seas Between and Near the Tropicks, with an Attempt to Assign the Physical Causes of the Said Winds." Halley rightly concluded that monsoons—winds blowing alternately from sea to shore and shore to sea—were caused by the temperature differences between land and water. He also demonstrated that the sun's heat near the equator was the primary cause of the trade winds. But he overlooked one very important factor in the winds of the world, which another Englishman, George Hadley, discovered in 1735. This factor is the deflective force due to the earth's rotation, which causes the southward-drifting trades to turn west, and leads the northward air drifts in temperate latitudes to turn east.

Around 1850, Heinrich Wilhelm Dove, one of the greatest of all meteorologists and climatologists, brought out in Germany his celebrated book on the "Law of Storms." He tried to give a fuller explanation of the great wind systems of the world, postulating two main circulations in each hemisphere: one between the equator and the tropics, the other between the tropics and the pole. He studied keenly the origin of large-scale storms—the cyclones or "lows" of temperate latitudes—and concluded that they were due to the continual strife between tropical air currents flowing up from the south and polar air currents flowing down from the north. This early idea of Dove's is, as we shall see, the germ of modern weather analysis methods that have recently revolutionized temperate-zone aerology.

Around 1850, too, Matthew Fontaine Maury of the U. S. Navy made his famous researches into the prevailing winds of the seven seas. Maury finally prepared complete charts of these winds, and by using his charts, sailing-ship

captains cut the time of long voyages by 25 per cent.

After Dove and Maury came many distinguished men, advancing theoretical meteorology in various particulars. William C. Redfield in America studied West Indian hurricanes and the storms of the Atlantic coast, finding that "a cyclone is constituted by a considerable mass of air endowed with a rapid movement of rotation in the direction opposite to the hands of a watch." William Ferrel, also an American, worked for many years on the problem of world air circulation, and published theoretical solutions that were accepted for some time. At the time of the American Civil War, Sir Francis Galton, working in England, wrote: "I have deduced . . . the existence not only of cyclones, but of what I dare to call anticyclones." And to-day, the anticyclone, or "high," is beginning to assume even more importance in modern weather forecasting than the traditional cyclone, or "low." In Holland, Buys Ballot framed his oft-reiterated law of pressure-wind relations: "If you stand with your back to the wind in the northern hemisphere, then the low pressure will be on your left hand"; and developed other important pressure field—wind field relations. Towards the turn of the century Hugo Hildebrand Hildebrandssen of Sweden and Leon Teisserenc de Bort of France revised Ferrel's theory of world winds, and in their "Fundamentals of Dynamic Meteorology" reduced all previous ideas of planetary circulation to the complete and unified theory that is generally accepted to-day.

IV

In the opening years of the nineteenth century the Chevalier de Lamark, working in France with Laplace, Lavoisier and others, established a network of weather stations and published a series of annual weather reports. Back in 1820, Heinrich Wilhelm Brandes, a German, had conceived a simple yet profoundly important idea. This was, in brief, that the wide-spread phenomena of the weather could best be studied by plotting on a map various weather observations taken at the same time, covering as large an area as possible. A year later William C. Redfield was drawing these synoptic maps of American weather conditions. But in those days, of course, the synoptic maps could not be made until slow mails had arrived from distant places—until the weather being studied had come, done its worst and gone.

In 1844 the first commercial telegraph clicked from Baltimore to Washington the devout message: "What hath God wrought!" At the same time men were suggesting, in various parts of the world, that the new electrical marvel be used to send weather reports from outlying stations in to control weather offices. But the first actual telegraphic weather reports were sent, also in the United States, in 1849 at the suggestion of the great electro-physicist Joseph Henry. He and James Pollard Espy (who had developed the convective theory of cyclones) organized the first regular weather service in the United States, now grown into our large, ubiquitous and immensely useful Weather Bureau. Like many another admirable American agency of peace, this weather project was born in our War Department; and the first official American weather forecasters were army officers detailed to that unaccustomed duty.

Espy and Elias Loomis greatly improved weather plotting methods. Under them the daily weather map grew towards the romantic tapestry it is today, showing at a glance all the morning's weather over the whole of North America from Alaska to Panama. Daily weather maps were introduced into England by Admiral FitzRoy, who in 1861

hazarded a storm forecast that actually came true. Soon after, in France, the astronomer Le Verrier began publishing a daily, up-to-the-minute weather map. Meanwhile, FitzRoy, together with Siljeström and Lilliehöök in Sweden, confirmed and elaborated some of the storm theories of Dove.

V

The first upper air meteorological sounding was made by Dr. Alexander Wilson, a Scotchman, in 1749. He tied a thermometer to a kite and sent it aloft to measure the temperature at upper levels. During recent years a score of airplane pilots scattered over the United States, and perhaps another score elsewhere in the world, have gone aloft each morning with much the same idea in mind; for Wilson really started, unknowing, the whole modern, much-publicized program of "air mass analysis." About 1809, Thomas Foster began to use in England small balloons rising freely as a means of determining the winds at upper levels, watching their drift from a ground observing station. Thus began "pilot balloons," which now ascend uncomplaining each day at all hours and in all weathers from three score stations in the United States alone.

During the late eighteenth and early nineteenth centuries the free balloon was in its heyday, daily carrying men to various adventures and not seldom to disaster. The first temperature measurements of the upper air were made by the aeronauts Jeffries and Blanchard in 1784. Soon the balloon was in common use for atmospheric soundings. In the eighteen-fifties John Welsh, of England, made several ascents up to an altitude of about 20,000 feet (higher than sounding airplanes go to-day), observing pressure, temperature and humidity at all levels. At about the time of the American Civil War, Scientist Glaisher and Pilot Coxwell rose above watchful England in a series of atmospheric soundings that left little to be desired for thoroughness and accuracy. One of their twenty-eight ascents reached an astounding altitude (considering their preparation and equipment) of something like six miles. These intrepid pioneers, incidentally, also attempted the first aerial photography and dropped the first aerial bombs.

Toward the end of the nineteenth century self-recording instruments were developed which made it unnecessary for men to go aloft after meteorological data. The smaller sounding balloons, or balloon-sondes, could go far higher without discomfort—easily to altitudes around ten miles and perhaps to twenty. In addition to his theoretical work, Teisserenc de Bort pioneered in France and elsewhere these high-altitude, small-balloon soundings. In 1901 he discovered the stratosphere or isothermal layer—that still, frigid region where temperature stops decreasing with increasing height. De Bort sent up his balloons from various points in Europe and from his steam yacht in the south Atlantic Ocean. In Germany, Richard Assman also sounded into the stratosphere with self-recording instruments. In the United States, Abbot Lawrence Rotch, of Blue Hill, sent up many sounding balloons to great heights, and collaborated with de Bort in studies which showed the variation in height of the stratosphere base from pole to equator.

The latest development in atmospheric sounding is the "raysonde" or radio-sounding-balloon, a small robot which sends back word of pressure, temperature and humidity being encountered as it rises through the troposphere and into the stratosphere. The first raysondes appeared around 1925, and a standard instrument went into quantity production in 1938.

VI

The present inspiring phase of meteor-

ological progress, so far as we know it, began during the Great War. About 1893, it is true, Frank Hagar Bigelow, of the United States Weather Bureau, had developed his "counter current" theory of the origin of cyclones, amplifying the earlier ideas of Dove. Bigelow thought that the interchange of air between equator and pole takes the form of great currents of unlike air, flowing side by side. The northward-moving currents, of tropical origin, are warm and moist; the southward-moving currents, of polar origin, are cold and dry. Twenty-five years later U. S. Army weather forecasters with the American Expeditionary Forces in France used technique closely approaching modern physical weather analysis.

But chief credit for the systematic building of all these early ideas into the unified and workable whole of modern air-mass-and-front theory and practice must go to a few weather analysts in Norway. Their work reached practical importance around 1918, and continues at the present time. Three of them are from one lineal line: Carl Anton Bjerknes, the grandfather, began with theoretical hydrodynamics in the nineteenth century; Vilhelm F. K. Bjerknes, the father, applied hydrodynamical theory to meteorolgical theory; Jakob Bjerknes, the son, translated this theory into practical applications. Collaborating with the younger Bjerknes are others of the Bergen school—notably Halvor Solberg, Tor Bergeron and Sverre Petterssen. The new ideas have been heralded under a variety of names, of which "polar front theory" and "air mass analysis" are the most common. But more accurately descriptive, perhaps, are "air-mass-and-front analysis" and "physical weather analysis." Here again invention sprang from necessity, for in the World War of 1914–18 the Norwegians were cut off from outside weather reports, and hence had to analyze their local and regional weather more thoroughly and completely than ever before.

The Bjerknes "polar front picture" first appeared in 1918. During the winter of 1923–24, Vilhelm Bjerknes, just beginning to get reliable routine results at Bergen, came to the United States and lectured at several institutions; this was the first real inkling of air-mass-and-front analysis to reach America. In 1926 Carl-Gustave Rossby came from Norway to America and, failing to interest the Weather Bureau in the new theories at that time, went to Massachusetts Institute of Technology, where as professor of meteorology he has since made important contributions to the science. The new ideas did not appeal at once to every conservative meteorologist accustomed to other viewpoints, and in some quarters they were tacitly or outspokenly opposed. But their present sweeping progress leaves little doubt that they represent a truer and more complete system of viewing weather phenomena than has ever existed before.

VII

This air-mass-and-front analysis of the Norwegians is based in general on five main ideas, simple enough in themselves, but somewhat complex in their complete application. These basic ideas are:

1. When air stagnates for some time over a distinctive geographic area, called a "source region," it acquires characteristics, such as temperature and moisture, in keeping with the current climate of the source region. For example: "polar" air is relatively cold, "tropical" air is relatively warm, "continental" air is relatively dry, "maritime" air is relatively moist. In general these characteristics are not limited to air near the surface, but extend several miles aloft.

2. Impelled by the general atmospheric circulation, large masses of air (hundreds of miles across and several miles deep) may travel long distances over the earth's surface, still retaining in some degree their source region characteristics, which are modified only gradually as the

air mass sojourns in a new geographic region. This modification is usually accomplished first at the surface, later aloft.

3. When two dissimilar air masses are brought together by the general atmospheric circulation they do not immediately mix; a definite boundary or discontinuity zone (perhaps five or more miles wide) occurs between them. Along and near the boundary colder (denser) air always underlies warmer (rarer) air in the form of a wedge; hence the "front" between the warm and cold masses (actually a mixing zone but pictured and spoken of as a discontinuity surface) is usually inclined at a small angle to the earth's surface.

4. Definite air mass interactions (producing variable winds, clouds, rain and other weather phenomena) occur along these fronts. The form and intensity of these interactions depend on the differences in characteristics of the dissimilar air masses involved, their extent, and the rapidity with which they are brought together.

5. In addition to this "frontal" weather, clouds, rain, and other weather effects may occur within air masses where the characteristics of the air mass itself favor them, and where terrain features and the motion of the air mass accentuate these characteristics.

It must be emphasized that air-mass-and-front analysis applies mainly to the temperate zones of the earth's surface. The tropics are under warm, moist, "tropical marine" air almost all the time, and this air varies in heat and moisture only slowly with the seasonal, north-south slow swing of the "apparent" sun. The arctics are likewise under fairly uniform cold, dry "polar continental" air most of the time. It is only in one of the temperate zones that a real "polar front" causes a continuous interplay of unlike air masses and large-scale cyclonic storms. However, the temperate zones in general, and the north temperate zone in particular, are where most of the world's people live, and where most of mankind's intellectual and material advancement is carried on.

Significant and revolutionary as the new air-mass-and-front analysis methods are, they have disproved no *physical* principles that came before them; nor will they. The wind is still "a flowing of air," as the ancient Ionian defined it. The rise of liquids in exhausted tubes is still due to an "outside pressure exerted by the atmosphere on the surface of the liquids," as Torricelli stated during the Renaissance. The large-scale storms of the temperate zones are still due, as Dove discovered when the United States was young, to the continual strife (now garbed in the nomenclature of air masses and fronts) between tropical and polar air currents. There is nothing absolutely new under the sun. But the world does move, and meteorology moves with the forward march of science.

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SKETCH OF THE DEVELOPMENT OF THE WATER CULTURE METHOD OF GROWING PLANTS

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THE history, development and use of the water culture and sand culture methods for the study of plants may be divided into four rather distinct periods: The first period began about 1700 and ended about 1800. The second period ended about 1860. The third period extended from 1860 to about 1900. The fourth period began about 1900 and continued to the present time.

The water culture of plants as it is known to-day probably had its beginnings in the work of Woodward[1] during the late years of the seventeenth century. Woodward grew several species of plants in different kinds of water: rain water, river water, spring water, conduit and distilled water, in an attempt to discover the so-called "principles of vegetation." He concluded that water is the carrier of "terrestrial matter" from which vegetables are formed, that earth, and not water, is the matter which nourishes the plants. This is the earliest record of experiments with water cultures. Following these early experiments with water as a culture medium other investigators of plants became interested, and prior to 1800 several series of investigations with water cultures are recorded. Thus Duhamel du Monceau,[2] in 1750, from the results of a comparative study of plants grown in soil and in water culture concluded that the plants in both cases had the same composition. This work was published in 1758. However, during this early period so little was known about the fundamentals of plant nutrition that there was small chance for any profitable outcome from such experiments, although during this period the conception of soil minerals as plant nutrients was developed. This paved the way for the extensive investigation of the assimilation of the ash constituents of plants carried out during the second period in the history of water culture development.

At the beginning of the second period, about 1800, some experiments with water cultures which had some real significance were carried out by de Saussure.[3] He investigated the absorption of certain salts by a variety of plants from various solutions. Some of his conclusions, at that stage in the history of water culture, had considerable importance and they were sometimes referred to as his "laws." He discovered that roots absorbed much more water than was required by the plant for nutritive purposes and that they extract much less of salt than of water from any given solution, and that all the salts in a mixed solution are not equally absorbed, thus laying the foundation for the concept of differential salt absorption by plant roots. He discovered also that roots absorb substances from solution regardless of whether these substances are essential in the metabolic processes of the

1 J. Woodward, Phil. Trans. Royal Soc. London, 21: 382–398, 1699.

2 H. L. Duhamel du Monceau, "La physique des arbes." Paris, 1758.

3 T. de Saussure, "Recherches chimiques sur la végétation." Paris, 1804.

plant or not, although Sprengel[4] was perhaps the first to assign specific importance to the essential elements, which he said could not be replaced by others, and to state specifically that not all the ash constituents are essential to the plant. This was a direct contradiction to the older view that roots had the power of selecting from the soil just those substances which the plant required and rejecting all others. The concept of differential absorption of ions from solution came as a much later development.

By the middle of the nineteenth century, sufficient information concerning the fundamental principles of plant nutrition and of plant physiology had accumulated through the work of such men as Liebig and Boussingault to lay the foundations for the beginnings of the real development of the water culture technique.

Liebig's[5] book, published in 1840, cleared the atmosphere of the many erroneous and misleading ideas of the time regarding not only the essential constituents of plants, but also the sources from which these constituents are derived. He was one of the first to correctly assign to the soil the rôle which it plays in the nutrition of plants, and recognized for the first time that the source of carbon in the plant is the carbon dioxide of the air. However, he denied oxygen respiration in the plant because of its connection with the elimination of carbon dioxide, nor did he understand the rôle of the soil as a source of nitrogen. The publication of his book on the application of organic chemistry to agriculture and plant physiology served as a great stimulus to the chemists and plant physiologists of the time toward undertaking the investigation of fundamental problems in plant nutrition.

Liebig's theory of the mineral nutrition of plants which attributed to the soil the function of supplying to the plant the mineral elements required for growth, as well as water, was experimentally verified by Boussingault[6] who grew plants in artificial soils consisting of inert, insoluble substances, such as quartz sand and charcoal which were watered with nutrient solutions of known chemical composition. By the use of these artificial solid substrates supplied with solutions of known composition, Boussingault was able to show that the minerals present in the ash of the plant were all derived from the soil and from the soil only. He further showed that plants were unable to make use of the uncombined nitrogen of the air, but were able to satisfactorily absorb their supply of this element from the solutions containing nitrates which he applied to his artificial soils in the complete absence of "humus," thus exploding also the outworn "humus theory" which postulated that the chief source of carbon and other essential materials for plant growth is the animal and plant wastes which accumulate in the soil. The honor of initiating the modern approach to the methods of investigating the inorganic nutrition of plants must be assigned to Boussingault, more than to any other, and in this approach water culture technique assumed a major rôle.

After it was once recognized, largely through the work of Liebig and Boussingault, that in the economy of the plant it is the chief function of the soil to provide the mineral elements required for growth and that these elements could

[4] C. Sprengel, "Die Lehre vom Dünger." Leipsig, 1839.

[5] Justus von Liebig, "Die organische Chemie in ihrer Anwendung auf Agrikultur und Physiologie." Braunschwieg, 1840.

[6] Boussingault. "Recherches sur la vegetation." (A long series of papers, publication of which began about 1837 and continued until his death in 1887.) References in "Agronomie chimie agricole et physiologie," 3rd edition. Paris, 1886.

be added, in the form of solution, to an inert, insoluble substrate from which the plant could effectively absorb these elements, it was then only a step further to attempt to supply the necessary elements, as well as water, to the plant independently of any solid medium, even an artificial soil. With this idea finally well established through the work of Boussingault it may be regarded as having brought to a close the second period in the history of solution culture of plants after a time lapse of about sixty years.

The third period in the history of water cultures began about 1860. The real development of the water culture technique was initiated with this period. It was the natural outgrowth of the more modern ideas about the fundamental principles underlying the nutrition of plants. After it had been discovered that plants could be successfully grown in an artificial insoluble medium supplied with the mineral salts in the form of solution and that a "natural soil" was not an essential, the attempt to grow plants in a water solution of known composition followed as the next logical step.

During this period the investigation of the pressing problems in the nutrition of plants followed two general methods. One of these was to compound an artificial soil of insoluble, inert constituents and add to it solutions of soluble salts which were known to be essential for growth. This method, introduced by Boussingault, improved and extensively used by Salm-Horstmar[7] has since 1860 undergone many technical improvements and has been employed by many investigators for experimental work. The second method is that of "water culture" introduced and successfully used for the first time by Sachs to determine what are the essential mineral elements required for the growth of plants.

The water culture method, as it is known to-day, had its beginning at the time when Sachs[8] published the first standard formula for a nutrient solution for plants in 1860. The original technique developed by Sachs is still used extensively, practically unaltered. He believed the water culture method to be valuable for the investigation of fundamental problems in plant physiology because it eliminated many of the unknowns of the soil and provided a means of chemical control not attainable in the complex soil system.

The very extensive researches carried out during the early years of this period by Sachs,[9] Knop,[10] Wolf,[11] Nobbe,[12] Birner and Lucanus,[13] and others with the technique developed by Sachs proved to be very fruitful. The results of this work placed the water culture method and the preparation of culture solutions on a very definitely scientific basis and established the values and usefulness of the method in dealing with problems of the growth and metabolism of plants in general. During this period many standard solution formulas for the growth of plants in water culture were proposed and published. The use of solutions of known composition enabled the investigators to differentiate definitely between the essential elements required for growth and development and the nonessential elements which are absorbed by

[7] Salm-Horstmar, *Jour. Prakt. Chemie*, 52: 1–37, 1851; also 54: 129–133, 1851, and a series of papers published in the *Jour. Prakt. Chemie* from 1849 to 1855.

[8] J. Sachs, *Landw. Versuchsst.*, 2: 219–268, 1860.

[9] J. Sachs, *Landw. Versuchsst.*, 2: 22–31, 1860.

[10] W. Knop, *Landw. Versuchsst.*, 2: 65–99, 270–293, 1860, and a series of papers published between 1860 and 1865.

[11] W. Wolf, *Landw. Versuchsst.*, 6: 203–230, 1864, and 7: 193–218, 1865.

[12] F. Nobbe, *Landw. Versuchsst.*, 7: 68–73, 1865.

[13] H. Birner and B. Lucanus, *Landw. Versuchsst.*, 8: 128–177, 1866.

the roots and appear in the ash of the plant. The elements required for green plants absorbed by the roots from the substrate were found to be potassium, calcium, magnesium, nitrogen, phosphorus, sulphur and iron. To these, as the result of later discoveries, must now be added manganese, boron, zinc, copper and perhaps some others. Another outstanding feature of the early investigations of this period was the observation by Knop, who concluded from the extent to which the several elements were absorbed by the plant from solution, that there was a greater resistance of the plant membranes to the penetration of sulphate than of nitrate. This observation suggested the concept of protoplasmic permeability as an important factor in the absorption of the various essential nutrient elements. The quantitative studies of Knop indicated clearly that the plant is able to absorb salts selectively under a wide variety of conditions. Even at this early period it was clearly recognized by the investigators that the composition of a culture solution could vary considerably without producing noticeable effects upon the plants provided only that the ranges in salt proportion were kept within certain limits and actual deficiencies of any of the required elements did not occur. Some of the nutrient solution formulas for the growth of plants which were proposed and published during the first decade of this period of solution culture history are still used extensively, notably that of Knop[14] published in 1865, which has perhaps been more widely employed than any other in studies dealing with the problems of plant nutrition.

The intense interest in water culture technique and its use in plant studies, which characterized the period between about 1860 and 1880 subsided emphatically during the last quarter of the nineteenth century and near the end of the century solution culture had practically fallen into the discard. Only a few researches of significance appeared sporadically in the literature during this time and the third period in the history of the water culture method came to an end with the close of the century. The progress which was made during these forty years had far reaching effects. It laid the foundations for more thorough study and a better understanding of the complex processes involved in the nutrition of plants. Furthermore, it had a profound influence upon the new science of plant physiology which marks its real beginning during the first years of this period. The investigations carried out during this period with the water culture technique have even to-day a tremendous influence upon fertilizer practices and soil management for purposes of large scale crop production.

The fourth and present period in the history of water culture and sand culture had its beginnings during the early years of the present century. It has been characterized by a vigorously renewed activity in the application of the water culture technique to solving the pressing problems of plant nutrition. This renewed activity followed immediately upon the discovery during the first decade of the century, of several new essential elements for plant growth. The fact that these newly discovered essential elements are required by the plants only in minute traces led to great improvements in the water culture technique, and great strides were made in the refinement of methods and in the purification of nutritive materials for accurate study. Better and more adequate equipment for the experimental set-up was devised and used. Through this great refinement of the water culture technique and improvement in the methods of operation

[14] W. Knop, *Landw. Versuchsst.*, 7: 93–107, 1865.

it is now possible to add to the list of essential elements for plants boron, manganese, zinc, copper and undoubtedly others will be added with still further chemical and physical refinements. A knowledge of the essential nature of these elements, although required by plants only in trace quantities, has already proven to be of definite practical importance in agricultural procedures for the commercial production of plants and plant materials.

During this present period many formulas for nutrient solutions have been proposed and published by Pfeffer[15] in 1900, by Crone[16] in 1902, by Tottingham[17] in 1914, by Shive[18] in 1915, by Livingston and Tottingham[19] in 1918, by Hoagland[20] in 1920, by Jones and Shive[21] in 1921 and others.

The newly aroused interest in the solution culture methods and the vigorously renewed activity in the experimental studies of plant nutrition during this period resulted in the development of new concepts relative to the processes involved in the absorption, assimilation and accumulation of the required elements by the plant from nutrient solutions. It led to the development of more accurate methods in following these processes in a quantitative way. As a result of this work it is now known that the elements are absorbed from solution in the ionic state and that the ions are selectively absorbed by the roots, and that this selective absorption profoundly influences not only the chemical composition and reaction of the nutrient medium but also changes some of the physical characteristics of the medium which in turn affect the activities and metabolic processes of the plant. A knowledge of the manner in which plants are capable of altering the physical and chemical properties of a culture solution suggested the desirability of renewing the nutrient supply at frequent intervals in order to overcome these disturbing influences in quantitative studies. This led to the development of various devices and mechanisms by which the culture solutions in either water cultures or sand cultures can be automatically renewed, without interruption, by continuous flow methods. Such devices have been used and described by Trelease and Livingston,[22] by Shive and Stahl,[23] by Johnston[24] and others, and they have played an important part in the development and effectiveness of the water culture technique.

It has been shown also through the work carried out during this period that plants can absorb from solution an excess of the nutrient elements beyond that required for maximum production if the elements are maintained in the medium in sufficiently high concentration. As the result of such studies considerable attention has been given to the concept of "physiological balance" of salt and ion proportions in culture solutions.

The intense interest and the remarkable activity not only in the development and use of the water culture technique

15 W. Pfeffer, "The physiology of plants." Translated by A. J. Ewart, Oxford, 1900.

16 G. Crone, "Ergebnisse von Untersuchungen über die Wirkung der Phosphorsäure auf die höhere Pflanzen und eine neue Nährlösung." Sitzungsber. Niederrhein. Gesel. Nat.-und Heilkundee Bonn. 1902: 167–173, 1902.

17 W. E. Tottingham, *Physiol. Res.*, Vol. 1, No. 4, May, 1914.

18 J. W. Shive, *Amer. Jour. Bot.*, 2: 157–160, 1915, and *Physiol. Res.*, Vol. 1, No. 7, Nov., 1915.

19 B. E. Livingston and W. E. Tottingham, *Amer. Jour. Bot.*, 5: 337–346, 1918.

20 D. R. Hoagland, *Science*, N. S., Vol. 52, No. 1354, pp. 562–564, Dec. 10, 1920.

21 L. H. Jones and J. W. Shive, *Jour. Agr. Res.*, XXI: 701–728, 1921.

22 S. F. Trelease and B. E. Livingston, *Science*, 55: 483–486, 1922.

23 J. W. Shive and A. L. Stahl, *Bot. Gaz.*, Vol. 84, No. 3, Nov., 1927.

24 E. S. Johnston, *Plant Physiol.*, Vol. 2, No. 2, 213–215, 1927.

but in all phases of plant studies has resulted in a greater advancement of the science of plant physiology in general and in a better understanding of the fundamental principles of plant nutrition in particular during the past quarter of a century than has been accomplished during all the previous years. Yet many of the most important problems relating to the nutrition of plants still remain unsolved and the water culture technique and culture solutions must surely be employed in their solution. It is important to call attention to the fact that the water culture method in its present stage of development provides a research tool of incalculable value in the hands of the trained plant scientist. It is also interesting to note that this scientific tool has been developed through the years without any thought toward its ultimate practical application to the production of plants and plant products on a broad commercial and agricultural basis. Until quite recently it was employed exclusively in connection with laboratory investigations dealing with fundamental questions of plant nutrition and physiology in which a high degree of experimental control is an essential feature. The scientific interest which has developed in this subject, and the importance which it has assumed in recent years, is indicated by the interesting fact that at the beginning of the present period in its history, very few laboratories engaged in plant nutrition studies were making use of the water culture methods. At the present time, on the other hand, there are very few laboratories seriously engaged in the investigation of problems relating to the nutrition of plants, which do not employ and benefit by these methods.

During a decade or more attempts have been made to modify and to adapt the water culture technique of the laboratory for the production of plants on a commercial scale in the greenhouse and in some cases with a considerable degree of success. Among the early efforts in this direction is the work of Gericke[25] at the University of California, Biekart and Connors[26] at the New Jersey Agricultural Experiment Station, Withrow and Biebel[27] at the Indiana Agricultural Experiment Station of Purdue University, Eaton[28] of the U. S. Department of Agriculture, Riverside, California, and Hoagland and Arnon[29] at the California Agricultural Experiment Station.

For the commercial growth of plants with water cultures large shallow tanks are employed to hold the culture solutions. Over the tops of tanks are placed wire screens to hold a bed of litter in which the plants are supported over the solution with their roots protruding through the litter into the solution below. The porous nature of the bedding litter which supports the plants and the shallowness of the tanks is supposed to provide an aerating system but actually does not supply an adequate quantity of oxygen for the needs of the plants. This adaptation of the experimental laboratory method of water cultures to commercial growing of plants was suggested and described by Gericke.[25]

A system less troublesome to operate than the water culture technique is an adaptation of the laboratory sand culture method which was probably first suggested for the commercial production of plants by Robbins.[30] Water-tight

[25] W. F. Gericke, *Amer. Jour. Bot.*, 16: 862, 1929, and numerous articles since published.

[26] H. M. Biekart and C. H. Connors, *N. J. Agric. Exp. Sta. Bul.*, 588, 1935.

[27] R. B. Withrow and J. B. Biebel, *Jour. Agric. Res.*, 53: 693–701, 1936.

[28] F. M. Eaton, *Jour. Agric. Res.*, 53: 433–444, 1936.

[29] D. R. Hoagland and D. I. Arnon, Univ. of California Cir. 347, Dec., 1938.

[30] W. R. Robbins, *Proc. Amer. Soc. Hort. Science*, pp. 368–370, 1928.

greenhouse benches are filled with inert solid material, such as sand, gravel, crusted trap rock or sometimes cinders. There materials are periodically flooded with the culture solution, either from above or from below, by the so-called sub-irrigation system, which is then permitted to flow back into a solution reservoir through a drainage system previously installed. This method provides adequate support for the plants, as well as an effective aerating system. It is the method which is most generally employed for the commercial production of plants in greenhouses. All of these methods are adequately described in the literature and their operation fully explained and they need no further mention here.

Since in these methods of growing plants on a large scale the culture solution takes the place of the soil in supplying mineral nutrients and water to the plants, they have been described under various names, such as "dirtless farming," "tray agriculture," "tank farming" and "hydroponics." Through the extensive publicity given to this subject by the popular press during the past two or three years it has caught the attention of the general public and has taken a prominent place in the interest and imagination of plant growers and plant lovers throughout the world.

The popular accounts of the recent activities with these methods of growing plants, which appear frequently in the newspapers and popular journals of all sorts, have created the impression that a new system of "soilless farming" has been developed which bids fair to revolutionize present methods of crop production and is destined to displace classical agriculture. Wholly unfounded claims have been made by promoters and popular writers who are completely lacking in knowledge of the first principles underlying the growth and development of plants in general and of plant nutrition in particular. Advertising schemes of all sorts hold out these methods of "soilless growth" to the unwary amateur as an easy road to quick profits.

It can not be too strongly emphasized that this recently publicized and so-called "new method of soilless growth" is merely the application of approved laboratory experimental water culture and sand culture procedure to large-scale technique. It involves no newly discovered facts concerning plant requirements, but has been developed on the basis of an understanding of the underlying principles of plant nutrition gained through investigations over a long series of years conducted on a laboratory scale. It should be pointed out also that solution culture and sand culture methods, whether employed on a laboratory scale or for commercial production, contrary to the impression which casual acquaintance with this subject might convey, are far from being proof against failure. Successful plant growing, either on a small scale or on a large scale basis, in soil culture, water culture or sand culture, is an exacting art, demanding a knowledge of technique, plant requirements, and plant behavior. The use of solution or sand culture methods of growing plants in no manner removes the necessity of such skill and knowledge. These methods do offer certain advantages over soil methods, particularly in the matter of nutrient control. On the other hand, certain technical difficulties encountered with these methods do not arise when plants are grown in soil, because in a soil made fertile by simple treatment, many of the factors which determine the nutrition of the plant are automatically adjusted.

While there is sufficient experimental evidence to indicate that the production of plants on a commercial scale by the water culture and sand culture methods is possible there is no authentic evidence

upon which to base the claims, all too frequently made, that yields produced by these methods are greatly superior in quality and quantity to those of plants grown in fertile soil under identical environmental conditions. On the other hand, it has recently been shown by Arnon and Hoagland[31] that yields produced by plants grown in culture solution on a comparative basis of season, time period, and experimental conditions, in both quality and quantity, were not greatly unlike the yields produced by plants grown in soil.

The history of the development of the water culture and sand culture methods and the experiences of the past eight or ten years in the attempts to apply this technique to the commercial production of plants and plant products makes it possible to predict that these methods can have no general agricultural significance in the near future, except perhaps in quite localized areas and under very special conditions. On the other hand, there is little doubt that in the near future this technique will play a major rôle in the commercial production of greenhouse crops. It is to be emphasized, however, that the water culture and sand culture techniques as they have been developed over the years are now, and must continue to be, a very important scientific tool for the experimental investigation of problems of plant nutrition, plant pathology, and other agricultural problems, and their application to large scale production is certain to promote their usefulness as an experimental tool.

[31] D. I. Arnon and D. R. Hoagland, *Science*, 89: 512–514, No. 2318, June 2, 1939.

THE CONTRIBUTIONS OF JOSIAH WILLARD GIBBS

TO-DAY the world is made clamorous by men who assert that they are strong and seem to be in a fair way of proving it. Just what place history will assign them remains to be seen, but there is no doubt as to their impact on our own time.

The world can well be reminded that history reserves some laurels for quiet people, and for peaceful achievement; the scholar has his place as well as the warrior. For those who in the non-political spirit of study release new knowledge, history reserves some of its best places. Such a one was Josiah Willard Gibbs, a graduate of Yale in the class of 1858 and professor of mathematical physics for over thirty years in the university. A complete example of the academic man, he was one of the great scientists of modern times, and one of the architects of the industry which is so important a part of our civilization. The one-hundredth anniversary of his birth will be observed in the present year. . . .

The first direct result of Gibbs's work was a great stimulus to physical science. He was the greatest single influence on the exact development of a new discipline—that of physical chemistry. He added greatly to knowledge concerning osmotic pressure and dilute solutions. He shaped our present concepts of chemical thermodynamics and electrochemical thermodynamics, and thus paved the way for an understanding of many metallurgical problems. The manner of this achievement was as remarkable as its content. Gibbs was not an experimenter, and there were few experiments to which he could turn. In building on the first two laws of thermodynamics he could go only where logic could take him, and the fact that he went so far is a tribute to a profound ability in mathematical reasoning. His work is marked by uncanny accuracy and simplicity and elegance of method. He never made mistakes, and everything that he did has survived all criticism. . . .

Gibbs fashioned a key to one set of natural forces; it is an accurate key, and its use is limited only by the occasions on which man wishes to investigate or control the forces coming under thermodynamic laws. With the great expansion in scientific activity, his formulae find uses over an ever-widening field of human endeavor. For example, many research programs in medicine are studies of the physical chemistry of the human body, and they bring into biological research the work of Gibbs. As industry depends more and more upon exact methods, the shadow of this quiet scholar falls more and more over the great establishments which are at the heart of our national economic life.—*From a Professor's Theory and its Practical Uses, Yale University.*

THE TRICHINOSIS SITUATION IN THE UNITED STATES

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DURING the last three years there has been considerable discussion in the popular and medical press on the subject of trichinosis. So far as can be ascertained from available information, the increased interest in trichinosis has not been stimulated by severe outbreaks of this disease, but rather by investigations which have uncovered infection with trichinae in human cadavers, these infections having been unaccompanied, apparently, during life by evident signs of illness. The facts brought to light by these investigations showed that a surprisingly large percentage of persons dying from various diseases in hospitals located, for the most part, in densely populated cities, contained trichinae in the muscles. The degree of infection discovered in the course of these investigations was on the whole very light, and was not considered by any of the investigators as the immediate or even a contributory cause of death. However, the discovery that in some cases 20 or more out of every 100 persons examined after death contained trichinae in the diaphragm produced considerable repercussion, and the subject of trichinosis is now being widely discussed in the public press.

HOW MAN ACQUIRES TRICHINAE

Human beings acquire an infection with trichinae solely as a result of eating the raw flesh of an animal that harbors these parasites. Animals become infected in the same manner. It is evident, therefore, that only carnivorous and omnivorous animals can transmit trichinae to man and to one another. Of the susceptible food animals that are slaughtered for human consumption in the United States, none are carnivorous and the hog alone has omnivorous habits. Pork is, therefore, the source of human trichinosis in this country. The only known exception to this general rule is the occasional transmission of trichinae to man by the consumption of bear meat.

PREVALENCE OF TRICHINAE IN SWINE

Although trichinae were first discovered in swine in the United States in 1846, no information was available as to the extent of infection with these parasites in hogs until some years after the establishment of the Federal Bureau of Animal Industry in 1884. Under the meat inspection act of March 3, 1891, provision was made for a microscopic examination of all pork intended for export, in order that certificates could be issued setting forth their freedom from trichinae. This act, the enforcement of which devolved upon the then 7-year old Bureau of Animal Industry, had the effect of lifting the restrictive measures against pork of American origin by the countries that had erected trade barriers against this commodity and incidentally supplied much needed information on the incidence of trichinae in swine in this country.

Out of 8,257,928 swine carcasses examined microscopically by federal inspectors between the years 1898 and 1906, approximately 1.5 per cent. were found to contain live trichinae and about 1 per cent. were found to contain what were regarded as dead or disinte-

grating trichinae, or bodies that resembled trichinae, giving a total maximum infection discovered by the microscope of about 2.5 per cent.

Following the abandonment of microscopic inspection for trichinae of pork intended for export, after the passage by Congress in 1906 of the new meat inspection act, the prevalence of trichinae in hogs in this country became largely a subject of speculation for nearly three decades. The figures commonly quoted in various articles on trichinosis were those that had been brought to light by Government microscopists up to 1906.

With the reawakened interest in human trichinosis stimulated, as already stated, by surveys on the occurrence of trichinae in human cadavers, the Federal Bureau of Animal Industry initiated in 1933 a survey to determine the status of trichina infection in hogs and to trace, if possible, this parasitic infection to its source. In planning this survey, the writer decided to use an improved method of examination, consisting in the digestion of the entire diaphragm of each hog involved in an artificial digestive fluid containing pepsin and hydrochloric acid.

It had been recognized for a long time that microscopic inspection of pork for trichinae is at best a hit and miss method, and that light infections could be discovered by this procedure only occasionally, since the quantity of meat that could be compressed sufficiently thin between glass slides to make the field visible through the microscope is necessarily very small. By the digestion technique, which is applicable to research only, a considerable quantity of meat can be examined, the results giving rather reliable information on the presence or absence of trichinae. When present, the trichinae are freed from the meat in the course of digestion and sink to the bottom of the vessel in which digestion is taking place. The parasites, whether dead or alive, are easily discovered by direct microscopic examination of the particles which settle in the digestive fluid.

By this procedure, there were examined between the years 1933 and 1938 approximately 25,000 diaphragms from as many hogs originating in the most important swine-breeding centers of this country. Of the samples so examined, 13,000 were obtained from swine that had been raised on farms and fed forage, grain and other feeds, including, in some cases, more or less garbage, and about 10,500 were obtained from swine determined to have been fed, as the main or a large portion of their diet, garbage as collected from municipalities and institutions. Leaving out of consideration the remaining samples obtained from hogs known to have been fed cooked garbage and which, as a consequence of this diet, had practically negligible infections with trichinae, the findings in the two groups of hogs under consideration were as follows:

Only 126 out of the 13,000 diaphragms from as many farm-raised hogs contained trichinae, whereas 599 out of the 10,500 diaphragms from as many garbage-fed hogs contained these parasites. Some lots of garbage-fed as well as farm-raised hogs were free from trichinae. The average incidence of infection in the farm-raised hogs was 0.95 per cent. and that in the garbage-fed hogs 5.7 per cent. In other words, the average incidence of infection with trichinae in garbage-fed hogs was six times as great as that in hogs raised on the farm. In both groups of hogs the degree of infection was very light in the vast majority of cases. In fact, between 70 and 80 per cent. of the trichina-infected hogs in the two groups had infections of a kind characterized by the presence of less than one larva per gram of diaphragm muscle tissue. Since the

diaphragm is known to be one of the preferred locations of these parasites, it is safe to conclude that the degree of infection in the positive carcasses as a whole was much lighter than that in the diaphragms.

It is obvious that in order to arrive at the present-day incidence of trichinae in swine in the United States it would be unfair to average the incidence findings in farm-raised and garbage-fed hogs, for the reason that the latter represent only a small part of the total number of hogs that come to slaughter. Precise information on the percentage of garbage-fed hogs that are marketed annually in the United States is unavailable. However, assuming that 10 per cent. of these hogs are garbage-fed, and some authorities on animal industry would regard this figure as being too high, the present-day average incidence of trichinae in all swine, based on the incidence findings discovered in our survey, would be approximately 1.5 per cent.

On superficial comparison, the incidence figure based on the newer findings is precisely that discovered by Bureau of Animal Industry microscopists between the years 1898 and 1906, during which period 1.5 per cent. out of more than 8,000,000 hogs examined microscopically were found to contain live trichinae. It must be borne in mind, however, that the incidence as determined by microscopic examination in previous years can not be compared to that determined by the digestion technique employed in our recent investigations. In order to arrive at a scientific basis of comparing the new incidence figure with that determined in previous years, samples from approximately 50 per cent. of the trichina-infected hogs, as discovered by the digestion technique, were also examined microscopically, three samples being examined from each diaphragm with the aid of compressor slides. Only 21 per cent. of the known positives, in the order in which they were detected by digestion, were found to show trichinae by microscopic examination. This is not surprising, considering the fact that between 70 and 80 per cent. of trichina-positive hogs in our series had exceedingly light infections, as previously mentioned. It would follow, therefore, that routine microscopic examination reveals trichinae only in carcasses that are moderately or heavily infected and fails to detect practically all of the light infections.

Assuming that the findings with reference to the incidence of trichinae in hogs discoverable by the two methods herein reported are generally valid, the incidence of trichinae in hogs discovered by Bureau of Animal Industry microscopists represented only about one-fifth of the real incidence. In other words, the incidence of infection with live trichinae in hogs during the previous period mentioned, was actually about 7.5 per cent. as compared to the present-day incidence of 1.5 per cent. This shows a sharp decline in the extent of trichina infection in swine during the past three and one-half decades and augurs well for a continued decline due to increasing progress in sanitary methods of swine production.

Control of Trichina Infection in Swine

While there is considerable comfort in the knowledge that there has been a decided decline in the extent of trichina infection in swine over a period of nearly 35 years, those concerned with the live-stock and meat industries must take cognizance of the fact that the present-day status of trichina infection in hogs still leaves much to be desired. The present incidence of trichina infection presents a challenge to livestock sanitarians, swine breeders and the

meat industry of this country, and indicates that much effort must be exerted to reduce the extent of and perhaps ultimately eliminate altogether this parasitic infection in swine. With the diminution of trichina infection in swine there will be, undoubtedly, a corresponding decrease of clinical trichinosis as well as non-clinical trichina infection in human beings.

The evidence presented in this paper shows that the feeding to swine of garbage as collected favors the spread of trichina infection among these food animals. Since hogs can acquire trichinae only as a result of eating raw, trichina-infested meat, it is obvious that such meat must be present from time to time in the feed. When garbage is a large or a major part, or the sole feed of hogs, these animals have a greater opportunity of acquiring trichinae than when garbage is fed to them only occasionally. The fact that nearly 1 per cent. of 13,000 farm-raised hogs were found to contain trichinae is conclusive evidence that these host animals must have had access at some time or other to scraps of raw meat, presumably pork, contained in home or other garbage that was intentionally fed or made available to them.

The role of rats in the transmission of trichinae to swine is still a somewhat debatable point. However, the exceedingly low incidence and low intensity of infection with trichinae in swine fed cooked garbage, as determined in the course of our investigations, would tend to relegate the rat to a comparatively unimportant role in the transmission of trichinae to swine.

Assuming, therefore, that raw pork scraps in garbage constitute the main source of trichinae for swine, the elimination of these parasites from hogs necessarily involves the elimination of uncooked meat and bones from garbage. In cases in which this is not feasible, the feeding of garbage as collected must be eliminated altogether in order to control swine trichinosis. These recommendations apply to farm-raised as well as garbage-fed hogs, because the evidence obtained in the course of our investigations, as already stated, shows that 1 per cent. of hogs raised on farms harbor trichinae. The elimination of commercial garbage feeding only would still leave a large residuum of infection with trichinae in farm-raised hogs. The extent of what this residuum of infection would be is shown by the following considerations:

During the year ended June 30, 1939, there were slaughtered under federal inspection approximately 38,500,000 hogs. On the assumption that 10 per cent. of these animals were garbage-fed and that 5.7 per cent. of these garbage-fed hogs harbored trichinae, nearly 220,000 of these hogs were probably infected with the parasites under consideration. Among the remaining 90 per cent. of the hogs slaughtered under federal inspection, about 345,000 probably contained trichinae, assuming roughly a 1 per cent. incidence of infection in these host animals. It is evident, therefore, that the elimination of commercial garbage feeding would reduce the number of trichina-infected hogs only by approximately 40 per cent. and would still permit the remaining 60 per cent. of trichina-infected carcasses to be sold as fresh pork. The effective control of trichinae in swine must involve, therefore, due attention to the feeding of hogs raised on the farm as well as garbage-fed hogs (in order to eliminate from the feed of these animals scraps of raw pork, bones, offal, dead rats) and to the proper disposal by cremation or deep burial in quicklime of all hogs and other animals that die on the farm.

Prevention of Human Trichinosis Through Federal Meat Inspection

The reduction to negligible proportions and the ultimate eradication of trichinae from swine represent sound goals in livestock sanitation. However, since ideal goals in various spheres of human endeavor are seldom attained, much good can still be accomplished by making a compromise between the ideal and the practical. Considering the difficulties involved in the eradication of trichinae from swine, much can be done and much has been done already to reduce the incidence of the disease, trichinosis, in man by certain meat inspection procedures.

It is unfortunate that nature made trichinae so small that their presence in a hog carcass can not be discovered by the naked eye. Encysted trichinae in the muscles are spirally rolled, the individual worms being enclosed in connective tissue cysts, approximately one fiftieth of an inch in diameter. Since the cysts and inclosed parasites do not stand out in sharp contrast to the meat, except in infestations of long standing, trichina-infected pork does not differ in appearance and texture from non-infected pork. In the course of routine inspection of hogs, trichina-infected carcasses, therefore, escape detection.

In the regulations governing the meat inspection of the U. S. Department of Agriculture, there is contained the following provision:

> Inasmuch as it cannot certainly be determined by any present-known method of inspection whether the muscle tissue of pork contains trichinae, and inasmuch as live trichinae are dangerous to health, no article of a kind prepared customarily to be eaten without cooking shall contain any muscle tissue of pork unless the pork has been subjected to a temperature sufficient to destroy all live trichinae or other treatment prescribed by the chief of bureau.

The treatments prescribed by the Chief of the Federal Bureau of Animal Industry for all meat food products containing pork muscle tissue that are prepared to be eaten customarily without cooking, are (1) heating, (2) special refrigeration and (3) special processing, these procedures having been found by extensive, painstaking scientific investigations to be adverse to the life of trichinae. Under the prescribed heating it is required that all meat food products of kinds mentioned must be so heated that they will attain in all parts a temperature of not less than 137° F. The required refrigeration involves the subjection of pork or of articles containing pork muscle tissue to a temperature of not higher than 5° F. for a continuous period of not less than twenty days, provided the meat or articles, not exceeding six inches in diameter, are hung up singly or packed in boxes not exceeding six inches in thickness. In the case of pork or products packed in barrels or tierces, the period of refrigeration is extended to thirty days.

Owing to more or less recent improvements in refrigeration, it has been determined that meat packing establishments operating under federal inspection commonly maintain their freezers used for treating pork to destroy the vitality of trichinae at temperatures much lower than 5° F. With this in mind, investigations were conducted recently by the Bureau of Animal Industry to determine the extent to which the required holding period of pork and products could be decreased if the temperature of the freezer is maintained at -10° F. The results of these investigations showed that when pork is packed in boxes not exceeding six inches in thickness, the required holding period in freezers maintained at -10° F. could be reduced to ten days and that when the meat or products are packed in tierces, the period of refrigeration need not be extended beyond twenty days. Tests

were made also with trichinous pork kept in freezers maintained at a temperature of –20° F. As would naturally be expected, it was determined that the required holding period at this low temperature for pork packed in boxes not exceeding 6 inches in thickness could be still further reduced, actually to six days; and for pork packed in tierces, the period could be reduced to twelve days. These results show, therefore, continued progress in investigations of and ultimate application of practical methods designed to destroy the vitality of trichinae in pork destined to be converted into products of kinds customarily eaten by the consumer without cooking.

Special curing methods prescribed by the chief of the Bureau of Animal Industry, in lieu of the required refrigeration or heating, involve the destruction of the vitality of trichinae by salt, at specified temperatures for definite periods. These curing methods, which are based on empirical formulae, were tested in the course of a series of extensive investigations and found to be effective in destroying the vitality of trichinae before their use was permitted in officially inspected establishments.

During a recent period of five years there were examined in the laboratories of the Zoological Division of the Bureau of Animal Industry over 10,000 one-half pound samples of meat food products originating in federally inspected establishments and designed to be eaten by the consumer without cooking. Each sample was examined by the method of digestion previously mentioned, and in no instance did any of these products contain trichinae capable of developing in human beings or in other susceptible animals. On the other hand, in the examination of 1,000 samples from products not processed under government requirements for the destruction of trichinae, 45 were found to contain live trichinae. These results show conclusively that processing for the destruction of trichinae, as enforced by federal meat inspection, is an effective safeguard against human trichinosis.

Possibility of Controlling Trichinosis in Man by the Skin Testing of Swine

About a dozen years ago the writer began experimenting with the skin test as a possible method of diagnosing trichinosis in live hogs. Since that time this subject has been under investigation in our laboratories, and during the past two years it has been one of our major research projects. The results of over 5,000 such tests made by Spindler and Cross, parasitologists of the Bureau of Animal Industry, were published some time ago. Six thousand additional tests made by these workers, the results of which are as yet unpublished, confirmed their earlier work and showed that, in the main, the extracts of trichinae to be injected into hogs (antigens) prepared by methods that were employed commonly in the past for the diagnosis of trichinosis in man can not be depended upon to give reliable results when used in hogs that come to slaughter.

Recently Lichterman and Kleeman, of the Board of Health of New York City, proposed a skin test for the detection of trichina infection in hogs, the results of which, according to these investigators, were nearly perfect. By following the technique employed by these investigators, tests carried out in our laboratories gave disappointing results. Only seven out of twenty trichina-infected hogs gave clear-cut skin reactions, four gave doubtful reactions and nine gave negative reactions. Out of 257 uninfected hogs, 106 gave clear-cut reactions, seven gave doubtful reactions and 144 gave negative reactions.

Continued work on the skin test is

progressing in our laboratory with encouraging results from time to time. Whether a skin test can be ultimately devised that will combine a high degree of specificity in detecting all, or nearly all, infected hogs and giving no reaction in all, or nearly all, non-infected hogs, can be determined only by additional investigations which must take into consideration, among other things, rapidity of the application and noting the results of the test, in keeping with the swift pace of hog killing which prevails in practically all establishments operating under federal inspection.

It must not be overlooked that an effective skin test, if developed and found to be practical, would apply only to hogs slaughtered under federal and other equally rigid inspection. Approximately one third of the hogs in this country are not slaughtered under such inspection; these would not, under present requirements, be subject to the test. Trichina-infected, fresh pork from this non-supervised slaughter would still be entering the channels of trade, unless the skin test were universally adopted. Considering the fact that but few States and not a great many municipalities enforce a rigid meat inspection, it is doubtful that a skin test for the detection of trichinae would be adopted in connection with all slaughter of hogs.

Summary and Recommendations

Considering the fact that approximately 1.5 per cent. of hogs which come to slaughter are infected with trichinae in varying numbers, it is essential that fresh pork and pork-containing meat food products of kinds not processed for the destruction of the vitality of trichinae, be cooked thoroughly in the home and public eating places. Meat-food products containing pork muscle tissue of kinds prepared to be eaten without further cooking are safe, provided they were prepared under Federal or equally competent inspection. Processors not operating under inspection would do well to adopt voluntarily the processing procedures developed by the Federal Bureau of Animal Industry for the destruction of trichinae. This should be done in the interest of human health as well as a protection from lawsuits growing out of trichinosis in human beings alleged to have resulted from the consumption of products sold as fit for consumption without subsequent cooking.

The elimination of meat scraps from garbage of all kinds, including that on the farm, or the elimination of feeding to hogs of garbage as collected, unless the latter is definitely known not to contain raw meat, will reduce sharply the extent of trichina infection in hogs. The prohibition of the feeding of garbage to hogs on a commercial scale alone will eliminate only approximately 40 per cent. of the trichinous hogs, assuming that this prohibition could be meticulously enforced.

Although the available evidence indicates a sharp decline in the extent of trichina infection in hogs during the past 35 years, livestock sanitarians, swine producers and meat packers must not relax their efforts in bringing about a continued reduction, even at a greater pace than heretofore, in the incidence of these parasites in swine. Such efforts, if carried out successfully, will eliminate from pork the stigma which now sometimes attaches to it, as being responsible for the production in man of the disease trichinosis, and non-clinical infection with trichinae.

THE RESPONSIBILITY OF EDUCATION TO SOCIETY

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I

THE attitude of man toward the responsibility of education to society has altered markedly, in keeping with the progress of human knowledge and culture. In primitive and oriental society education was informal and consisted chiefly in conserving the culture of the past and transmitting the customs and the traditions of the community. Education was, thus, a religious as well as a social duty. There was little comprehension of the idea that man should pass on the cultural tradition for the purpose of improving human society. It was taken for granted that the social order was the work of the gods and, hence, was as perfect as it could well be. Indeed, the very idea of altering or criticizing the accepted social tradition would have been an act of impiety. It was firmly believed that the best, indeed the only, way of insuring prosperity and security was to retain the existing social order unchanged and unquestioned.

The Greeks were the first to challenge this attitude. The Ionic philosophers were the earliest human thinkers to reject the traditional account of things and to bring the resources of the human mind to bear upon the analysis of traditional interpretations of nature and social institutions. The later Greek philosophers not only extended this critical function of human thought, but thoroughly comprehended the fact that education might be made a fundamental instrument of social reform and a major agency in promoting human progress. Indeed, in his "Republic," Plato proposed that the control of society should be placed in the hands of educators and philosophers. But such revolutionary ideas as these were restricted mainly to the philosophical students of education. The formal education of classical times, except among the few advanced students of philosophy and science, was still devoted mainly to transmitting and re-enforcing the mores, institutions and ideas of earlier generations. The central element in respectable classical education, namely, rhetoric, was well designed to promote intellectual conservatism and docility.

In the Middle Ages, education was primarily given over to inculcating both divine truths and social tradition. It employed rhetoric, logic and theology to create a well-rounded and coherent body of knowledge designed to give finality to the approved social structure. In practice, it trained youth to participate dutifully and efficiently in feudal society or in the bureaucracy of the church and the state.

Neither Humanism nor Protestantism wrought any fundamental revolution in the social attitudes underlying education. While they may have contributed to the criticism of Catholicism and certain institutions which the latter controlled or favored, both Humanism and Protestantism were primarily interested in the transmission of antique tradition —one in a literary tradition and the other in a theological heritage. Both placed a new emphasis upon the individual, but neither made any important contributions to the idea of the responsibility of education for the reconstruction of society.

With the coming of the period of enlightenment we encounter a revival of the Greek idea that education may pro-

mote human happiness and well-being, both through training the individual and by reconstructing society. The eighteenth-century "perfectionists" were the first important modern champions of education as an instrument of social progress. They believed that education should be universal and that it would wipe out individual inequalities and antiquated obstacles to human happiness.

These educational doctrines were warmly espoused by James Gordon Carter, Horace Mann, Henry Barnard and other American apostles of education as an instrument for the promotion of democracy. They labored mightily to bring about free public education. But altogether too little attention was given to the content of the education which, it was hoped, would extend and perpetuate the democratic experiment. For the most part, the democratization of education consisted mainly in passing on the older heritage to a larger group. Though we have seen to it that everybody can now go to school, we have been far less wise and proficient in making it certain that what our children study in the schools is of direct relevance to the solution of our public problems. Since the days of Horace Mann, we have assumed to be interested in educating the common man for the duties of citizenship in the contemporary world. Yet, in spite of the highly novel character of our civilization, the basic content of reputable education still remains roughly similar to that which was deemed suitable for the instruction of the children of the European nobility three centuries ago. Indeed, one of the most widely discussed of the recent plans for revamping our present system of education proposes to revive the educational attitudes and curriculum which were utilized to train prospective priests in the thirteenth century.

The educational innovators of the period of the enlightenment, such as Rousseau, were interested in the responsibility of education for both the personal development of the child and the reconstruction of the social order. But even our most progressive professional students of pedagogy have remained chiefly absorbed with educational responsibility for the individual, ignoring the fact that no individual can secure proper development in a cramped and restricted social environment. Education helped to strike off the chains of punitive discipline, but it gave little heed to the equally paralyzing fetters of an oppressive and inequitable social order. Social philosophers, such as Henri Saint-Simon, Auguste Comte and Lester F. Ward, vigorously emphasized the need for social planning and the vital relation of organized education thereunto. But our pedagogues gave little heed to their teachings and exhortations. Even in our own day, when certain educators with a sociological perspective are shocking many by their supposed radicalism and daring, we find that they are doing little more than setting before us the sociological doctrines which were the common property of social philosophers more than a half century ago.

II

The failure of education to become alert to its responsibility for bringing about constant readjustments in the structure of society and in our social thinking has helped to create the outstanding social crisis of our generation, namely, the tremendous and ever-widening gulf between our mechanical equipment, on the one hand, and our social ideas and institutions on the other. Scientific and technical education have made it possible for us to create our impressive and efficient empire of machines. But our hesitation and timidity in using education as an instrument for social planning have enabled our machines rapidly to outdistance the social procession. We stand, to-day, with our mechanical foot in an airplane and our social foot

tion to society boils down to three major phases of educational activity: (1) a highly discriminating conservation of the social heritage; (2) thoroughgoing and fearless social criticism; and (3) resolute and informed social planning.

It is as important as ever that education should pay attention to transmitting the heritage of the past. Without this knowledge, especially the knowledge required to operate our present technology and social system, man would be far more helpless than he would have been in primitive society without the support of the wisdom of the elders. But there is no longer any reason why we should uncritically accept the total social heritage. Indeed, we can not safely do so. Our past tendency to do this has created the social crisis of our day. We must view the heritage of the past from the vantage point of current knowledge. We must sift the social heritage through informed analytical examination. We must eliminate from serious consideration those obstructive antiques which are holding us back from bridging the gulf between technology and institutions. We are, to-day, equipped to discriminate between those aspects of the social heritage which have been tested and found valid through social experience, and those which are, obviously and flagrantly, the product of past ignorance, superstition and dogma. Further, we must create a critical attitude toward the heritage from the past, which will free the mind of the educated man from both reverent gullibility and cynical contempt.

In sifting the social heritage and in the creation of a mental attitude favorable to this process, historical studies can make the most direct and potent contribution. Indeed, this is probably the only important practical contribution which the study of history can make to education as an instrument of social progress. But this potential contribution of history is important indeed. We can not take even the first step toward bridging the cultural gulf and preserving civilization until we are able to assume a critical and analytical attitude toward our social thinking and institutions. This possible service of historical insight to social betterment constituted the main contribution of James Harvey Robinson to both historical study and the science of education. It may some day be regarded as one of the outstanding contributions of the twentieth century to constructive educational doctrine. Certainly, nothing is more urgently needed than the capacity to face the past with discriminating appreciation, free alike from both reverence and cynical indifference. No other study, save history, assumes any direct responsibility for bringing about such a result.

This creation of an intelligent attitude toward the past is indispensable as the preparation for the second major function of education, viewed as an instrument of social progress, namely, a critical appraisal of the existing social order. We can not even approach the present structure of society with any degree of objectivity unless we can view its origins with tolerant understanding. Likewise, we can not even be interested in working for a better social future until we are clearly aware of the weaknesses and inadequacies of the social order in which we live. It is for this reason that social criticism constitutes an extremely important item in the responsibility of education to society.

In the same way that history can best serve us by encouraging a discriminating appraisal of the past, so the other social studies must supply us with the means of critically assessing the social structures of our own time. This task of resolute social criticism constitutes an important phase of the descriptive work of the social studies. The first responsibility of the latter is to describe, realistically and completely, every aspect of the society in which we move. If this job is well done, the critical function of the social studies will emerge naturally and in-

evitably. Any competent description of, say, our social, economic and political institutions, will inevitably reveal their weaknesses and failures as well as their strength and success. Social criticism is, obviously, not the sole task or responsibility of the social studies, but it is certainly an indispensable phase of their contribution to the educational process. Until we are made completely aware of the defects of the existing social order we can have neither any incentive to work for a better social future nor any precise conception of what is actually required to bring about a better day.

The most immediate responsibility of education to society, right now, is therefore, the preparation of a blueprint of a better social system and a realistic indication of how we may bring this into existence in a gradual, peaceful and intelligent fashion. This is not merely a theoretical responsibility of education. It is a highly immediate and practical social necessity. We have already made it clear that human society is rapidly approaching the parting of the ways which lead to utopia or to chaos. The guidance of society by realistic education appears to many to be the only guarantee that we could choose the road to utopia. Certainly, it provides the only reasonable hope that this choice can be made without violence and destruction. Education has a very definite self-interest in this matter, on its own account. Unless we avoid economic collapse, social chaos, dictatorship and war, organized education can not be maintained in a state of dignity, independence and social prestige. Education must save democratic civilization if it is to save itself.

That this responsibility of education for reconstructing the social order is a very real and immediate one is readily apparent the moment we examine current world conditions. Many of the most essential aspects of American civilization, such as representative government, democracy, civil liberties, individualistic capitalism and private business enterprise have already disappeared or been thoroughly undermined in about two thirds of Europe. They are non-existent, or threatened, in most of the remainder of the Old World and in a considerable portion of Latin America. In the United States, we are paying around $5,000,000,000 a year in emergency expenditures simply to keep the capitalistic craft afloat, without any serious thought of weighing anchors and moving to more hospitable ports. And there seems to be every prospect that we shall have to pay more in the future, and get even less evident social advantages therefrom. As was painfully evident in 1937, even a slight letting up in salvaging expenditures caused the old boat to list dangerously and threaten to sink. In those countries where education failed to assume its social responsibility while there was yet time, education has been subordinated to propaganda and dogma, its independence and dignity shorn away and its curtailed personnel reduced to servility by intimidation.

If American educators evade their responsibilities in like manner, it is hardly to be expected that they will be preserved from a similar fate. There is no reason to believe that a totalitarian dictatorship can not easily be set up here, provided social conditions become ripe for one. And there are numerous and powerful elements in American society to-day who seem determined to create those social conditions out of which dictatorship and totalitarianism naturally and inevitably spring. And these elements are the very ones who are now most vociferous in detecting dictatorial symptoms in the New Deal.

It may be well to emphasize the fact right here that when I refer to "a better social order for the future" I am not remotely implying that we should imitate Soviet Russia or even create a moderate socialist régime. I have in mind only the very minimum reforms which

might, possibly, make American democracy and capitalism workable for at least a generation. In order to avoid the charge of dealing only in vague generalities, I will briefly summarize what I conceive to be some of the more essential reforms of this character.

To make democracy workable we will have to introduce a number of sweeping changes. Some type of weighted or selective suffrage system will be required, wherein the vote of an able and well-educated person will count for considerably more than that of an illiterate moron. We must greatly extend the civil service system, so as to cover candidates for every type of office, executive, legislative and judicial. No man should be allowed even to be a candidate for any important office unless he can formally qualify for the responsibilities of the post in question. Our present archaic system of representation by territorial districts must be supplanted or supplemented by vocational and proportional representation. This would introduce realism and democracy into our system of representative government. The power of the Supreme Court to set aside federal legislation must be greatly curtailed, if not entirely eliminated. A system of responsible cabinet government, roughly similar to that of Great Britain, must be introduced. There is not the slightest chance that we will be able to survive as a democratic nation if we attempt any longer to operate a government based upon the absurd separation of our governmental structure into three independent and balanced departments—a political monstrosity taken over by the inexperienced fathers of 1787 from a misinterpretation of the British government by an ill-informed French publicist, who wrote a generation before the American Revolution.

To give capitalism the slightest prospect of survival and efficiency we would have to bring about reforms even more sweeping and drastic than we have suggested with respect to democracy. Our system of banking and credit will need to be as thoroughly nationalized as our monetary system is to-day. Holding companies, "the machine guns of the corporate racketeers," will need to be speedily legislated out of existence. The scandalous waste of our natural resources must come to an end, and a vigorous program of replacement and rehabilitation adopted. The sabotaging of potential production and technological efficiency by such policies as the rejection of new inventions, limitation of output, monopolistic restrictions and the like, must cease. And the price structure must be overhauled to conform with the opportunities afforded by the mass-purchasing power of our citizens. State capitalism will need to be greatly extended, so as to include the federal ownership and operation of railroads, electric utilities, coal mines and, perhaps, the heavy industries. Legislation will have to be provided to insure much higher minimum wages and a much more adequate scheme for the spreading of work. We must look forward to a far greater range and volume of public works, even in normal times, with much more elaborate plans drawn up and held in readiness for those moments of emergency created by depressions. Collective bargaining must be legalized in fact as well as in letter. Finally, there must be a marked development of cooperative economic enterprise to supplement both state and private capitalism.

We must have a type of farm legislation which will insure sufficient income for the farmers without placing a premium upon non-production. In other words, we must insure enough profitable farm production to provide everybody with a liberal diet—something which only one tenth of the American families have ever been able to enjoy, even in Coolidge days. Our laudable beginnings in social insurance legislation must be greatly extended to provide really ade-

quate unemployment benefits and to give better protection to old age. If persons over 40 can not find employment, which is now the case, the government must either support them by old age pensions, or provide work for them on public-works' projects. Twenty-five years is rather too long to wait on an empty stomach. The government must see to it that the benefits of scientific medical care are made available to every American. If this can be done by some form of private group practice, rather than by completely socialized medicine, so much the better. If not, the government will have to step in and set up a compulsory system of health insurance and state medicine. To support these indispensable extensions of governmental activity, we must provide for a realistic scheme of taxation in proportion to capacity to pay. The human budget must take precedence over the treasury budget.

These reforms may stagger many, but even they do not give any promise of permanently solving the problems of capitalism. We face an unpredictable degree of technological unemployment and an enormous increase in the efficiency of farming methods. Dr. O. W. Willcox has made it clear that we can produce all the food needed for a high standard of living with one fifth of the personnel now engaged in agriculture, cultivating one fifth the land now being actively farmed. And even he does not reckon with the future production of many basic foods by synthetic methods in the chemical laboratories, independent of contemporary agricultural enterprises.

If this brief summary of minimum reforms proves at all terrifying, let those who are scared turn to Germany or Russia and find out if they prefer conditions there to those changes which I have outlined. There is no alternative. If we are to follow the "middle way" between Fascism and Communism, then we must not hesitate to adopt the middle way. We can not get anywhere simply by viewing it from afar. If we hesitate too long, we shall have no opportunity even to try any middle way. As Max Lerner has warned us, "it is later than we think." We can not save ourselves from Fascism unless we move resolutely within less than a decade.

This brings me to what I believe is the most important observation I have to make, namely, if education is to assume social leadership it must cease to be satisfied with abstractions, however sound and benevolent. I have been reading over the three volumes just published by the Educational Policies Commission. As a summary of general principles they leave little to be desired. As a specific guide to what education must teach with respect to solving our immediate social problems they offer us little or nothing. It avails little to talk about the "abundant life" unless we can know just what we must do to secure the abundant life. We can not fight off the very concrete realities of Fascism merely by mouthing lyrical generalities about the glories of democracy and free business enterprise. Education must make clear its position with respect to such things as holding companies, monopoly, the labor movement, cooperation and the like. It has no hesitation in declaring itself against disease in the physical world; it must be equally willing to condemn political, social and economic evils. Education must not only teach us to think straight but also how to act straight in the midst of our social perplexities.

IV

How well does the American educational system of to-day measure up to the responsibilities thus imposed upon it by our critical age? The recent studies which have been made are, to put it mildly, not reassuring. We may first take up the verdict of educational experts.

The already famous Regents Inquiry into the condition of public education in New York State, made it abundantly clear that the most expensive public school system in our country has failed to train our youth for citizenship, community life, remunerative occupation or competent further study.

The Carnegie Foundation for the Advancement of Teaching executed another comprehensive study, this time of education in Pennsylvania. This investigation of high school and college education revealed the fact that a quarter or more of those attending college in Pennsylvania were incompetent time-servers, without the mental ability to qualify them as intelligent and worthy college students. Believe it or not, a considerable proportion of them seemed to know less the longer they remained in college. Fifteen per cent. of them made a worse showing with respect to information in their senior year than in their sophomore year. Indeed, the least competent quarter of the college seniors knew less than the best third of the high school graduates. Interesting light was also thrown upon the competence of teachers in the state teachers' colleges. It was literally demonstrated that the best one fifth of the high-school graduates knew more than the poorest one fifth of the teachers they would study under in a state college.

We may conclude from these two highly competent investigations, which can hardly be accused of any Muscovite inspiration, that neither our high schools nor our colleges are producing anything to be proud of in the way of furnishing adequate training for the responsibilities of a democratic civilization.

We have already suggested that the functions of realistic education should be a highly selective conservation of the social heritage, a fair but resolute criticism of the social order, the formulation of a program for the improvement of society, and an indication of peaceful and intelligent methods of executing this program. Let us see how well education is executing these major social responsibilities of to-day.

Viewed in any broad and fundamental way, we must honestly admit that education blindly conserves the heritage from the past, without any important pretense to critical selection, save in fields of science and technology. With respect to our basic institutions and beliefs, our educational system conserves the past as completely and religiously as did the primitive council of elders and the tribal medicine men. Any resolute attempt to reject or discard fundamental items in our cultural heritage would immediately place in jeopardy any educational system or any body of educators. Indeed, the very proposal to do such would be regarded as rank heresy and a fit subject for investigation by the Dies Committee. Even our most daring educational reforms are, essentially, only superficial suggestions for improving the structure and administration of an educational system which is committed primarily to a reverent transmission of our ancient heritage.

There is also amazingly little criticism of our social order, though such criticism is absolutely indispensable if we are to discover those weaknesses which threaten the very existence of free and orderly society and are to recognize the alterations which are essential, if civilized decency is to prevail. We live in an age which has given unprecedented lip-service to the necessity and saving virtues of social research and organized investigation. We contend that "facts will talk," and we propose to let only facts talk. Tens of millions of dollars have been freely spent, no small part of this squandered, in order to investigate every conceivable type of secondary social problem. Yet, instead of actually letting the facts talk, our investigators have seen to it that disagreeable and challenging facts "shut up and pipe

down." Such facts as are played up are all too often the conventional, the self-evident and the platitudinous, so that much social research has been no more than expensive and pompous documentation of the obvious. Many of these investigations have been supported by funds derived from sources which would not tolerate effective and searching social investigation, or the clear formulation of the momentous conclusions naturally flowing therefrom. Indeed, most of our social research, timid though it may have been in drawing deductions, has been devoted chiefly to trivialities and details, and has rarely made any pretense to investigating the adequacy and efficiency of our basic institutions. Education has, thus, failed as signally in its critical analysis of our own social order as it has in a discriminating appraisal of the cultural heritage from the past.

The function of social criticism has been allowed to go by default to government investigators, journalists and free-lance economists and publicists. One has only to mention such representative names as Stuart Chase, Gardiner Means, Abraham Epstein, Charles Austin Beard, Herbert Agar, Lewis Mumford, David Cushman Coyle, George Seldes, Ernest Sutherland Bates and Alfred Bingham to realize the extent to which realistic social criticism is carried on outside academic circles. Not so long ago it was my pleasure and privilege to give a series of lectures before graduate students of education in one of our foremost schools of education. I was surprised to find that the students were actually thrilled and excited over information that would have been a commonplace to them in their junior high school period, if education were fulfilling its function in social criticism.

When we realistically examine the achievements of contemporary education in planning for a more equitable and efficient social order, we find that it has been even more deficient than in selecting what we shall accept from the past or in criticizing what we have to-day. When we appraise formal education from this point of view, realistic observers must admit that it is, quite literally, a liability to the human race—a veritable social disaster. Far from even indicating the desirability of a better type of civilization, organized education tends to breed reverence for the present social order. It distinctly and deliberately loads the dice in behalf of cultural tradition and social stagnation. It stimulates a spirit of social intolerance rather than an attitude of courageous experimentation. It tends to discourage even the minimum reforms necessary to preserve a democratic civilization.

We have made it clear that science and technology are widening and deepening the already menacing gulf between machines and institutions. Yet the prevailing attitude of most scientists and engineers is one of social quietism. Our scientists tell us that science may create unprecedented material advances and social maladjustments, but it can not furnish us with any immediate, direct and authoritative guidance as to how to meet these problems with expert intelligence. This is the message of the recently elected president of the American Association for the Advancement of Science,[1] himself one of the outstanding American social scientists. The scientists are quite willing to assume the responsibility for "advancing science," but they hang back when it comes to "advancing society." They ignore or evade the obvious fact that, unless our social institutions overtake scientific and technical achievements, all will go down together in a common ruin before many generations have passed. Certainly, if science can not lead the social procession nothing can. For those who wish to follow out this line of thought I would com-

[1] W. C. Mitchell, "Science and the State of Mind," *Science*, January 6, 1939.

mend the stimulating book of Robert S. Lynd, entitled "Knowledge for What?"[2] a much needed and resolute arraignment of the quietism and evasive philosophy of our intellectual leaders in the social studies movement.

Not only does organized education fail to execute its indispensable function of social guidance; its leaders even assume an attitude of savage hostility and professional intolerance toward the few educators who realize their social responsibility and make even a faint-hearted effort to do their duty. Donald Slesinger tells us that not one prominent professor who has been dismissed for his liberalism and later vindicated by the American Association of University Professors has ever again been able to secure a satisfactory academic appointment. And it has been the professors, rather than presidents and deans, who have been responsible for this scandalous state of affairs. Yet, when we examine the content of the teachings of these so-called subversive educators, we find little cause for any alarm—unless it be the discovery that they are, all too often, merely false alarms.

Our educational sociologists have stolen no thunder from Stalin, or even from Norman Thomas. At the best, they are only giving us what Lester F. Ward said more candidly and far more thoroughly over fifty years ago. Even John Dewey, rightly regarded as our most stimulating and progressive educational theorist, rarely presumed to get explicit in the matter of social guidance until he left the profession of education for that of active political agitation. When Dewey entered the political arena he gave us something that we can actually bite into. But not even one out of ten of Dewey's ardent pedagogical disciples has the slightest familiarity with Dewey's doctrines, expressed as a leader of the League for Progressive Political Action and the People's Lobby.

The timidity and irresolution of even our progressive educators can be illustrated by an example well known to some in this audience. That excellent journal, *The Social Frontier*, presents a very moderate social reform philosophy, advocating only the very minimum of changes which might be expected to make the present social order workable. Yet, a number of our most publicized and most popular educational leaders have taken the editors sharply to task for their alleged radicalism. And, in turn, some of those associated with *The Social Frontier* recently gave evidence of acute alarm over so indispensable and so mild an organization as the American Federation of Teachers.

One of the most notorious examples of sham and hypocrisy in the campaign against our quasi-liberal educators is the hue and cry against indoctrination. It turns out that indoctrination is nothing more than the teaching of moderately liberal ideas with respect to education and social reform. This charge is never raised against those educators who inculcate with a far greater degree of smug dogmatism the most reactionary social and educational conceptions. Indoctrination, as an epithet, turns out to be no more than the pedagogical adoption of the "name-calling device," so widely employed in contemporary propaganda.

Whatever the important and worthy services of liberal teachers to other aspects of education, it is no exaggeration to say that there is not one prominent educator in a responsible and reputable academic post in the United States to-day, who is devoting himself primarily to teaching the essentials of a better social system or telling us how to effect the transition from our own social order to a more desirable one. And if such an educator should suddenly arise, he could not hold his position for six months, if his activities and teachings were noised about. Our educators, even our most progressive educators, are primarily interested in saving their jobs, not in saving civilization.

[2] Princeton University Press, 1939.

For this I do not blame them especially, but they should not ignore the long-time consideration that, if we have no civilization, we shall have no jobs for anybody, least of all for educators.

Right now, one of the most discussed aspects of the social responsibility of education is that of preserving democracy in the face of the challenge of totalitarian dictatorships. This subject has been discussed with intelligence and realism by President Clarence A. Dykstra, of the University of Wisconsin, in his presidential address before the National Municipal League last December. It is entitled "Democracy at the Crossroads," and is reprinted in part in the January, 1939, issue of the *National Municipal Review*. President Dykstra suggests that, if we wish to preserve democracy in the United States, we must take a leaf out of the dictators' book, so far as mass education is concerned. To-day, we have the problem not only of improving democracy, but even that of maintaining what democracy we have at hand. If we are to succeed in this twofold task, we must muster all the resources of mass education and direct them to this end. As President Dykstra puts it:

> Perhaps one of these days we shall have to decide that even here in the United States all of our educational facilities—schools, press, radio and the screen—will have to be marshalled together in an effort to give the American people an understanding of the problems facing our civilization and our democracy. . . .
>
> If we still believe in democracy perhaps the world situation warns us that we must develop at least for a time a conscious educational program which will give democracy a chance for survival and for demonstrating that it can meet the challenges inherent in modern life. . . .
>
> It is a common saying that eternal vigilance is the price of liberty. If, then, freedom and liberty be worth struggling for, let us use our far-flung educational and communication devices to help us in that struggle. The freedom of these agencies themselves may be at stake.

As an abstract formulation of the situation, one could hardly improve upon President Dykstra's statement of the case. But it is necessary to remember that democratic and capitalistic society must be reformed and made workable if it is actually to be preserved. We shall get nowhere at all merely by parroting the threadbare phrases of traditional democratic propaganda. If democracy is not reconstructed in such a fashion as to adapt it to the responsibilities of our age, no amount of fulsome praise or intriguing rhetoric can preserve it.

President Dykstra is a very liberal and courageous university president. But I think I may be permitted to hazard the doubt that he would appoint to a social science professorship any man with a public reputation for daring to state clearly the essentials of a social program which would preserve American democracy. If this be true of President Dykstra, what shall we say of the averagely liberal American university executive, one of the most famous of whom was overheard recently lavishing hearty praise upon the stalwart Americanism and salutary statecraft of Mayor Frank Hague of Jersey City?

There is a still further obstacle in the way of using education as an instrument for operating and maintaining democracy. I believe it is not at all unfair to observe that even the Carnegie Foundation for the Advancement of Teaching would itself be acutely and vastly alarmed over the introduction of a curriculum which would make democracy operate effectively. As Horace Coon has suggested in his important study of foundations, "Money to Burn,"[3] truly democratic government and education bring forth from our foundations the pained cry that we are trying to destroy both education and research.

Indeed, the whole conception of education in the role of social leadership constitutes a definite paradox. Education is supported, for the most part, by those who vainly wish to preserve the existing social and economic order intact. How

[3] Longmans Green, 1938.

can we expect those who support education to encourage teachings which will undermine and modify the present scheme of things? Obviously, only by convincing them that essential reforms are the most certain way of preserving what can be saved from the impending wreck of the present social order—that reform is the safest way. But even such a campaign of persuasion is both dangerous and difficult, a fact amply demonstrated by the reception accorded to the New Deal by the vested interests.

Even those educational investigators who are realistic enough to point without hesitation to the defects of our current system of education have little to offer us, except suggestions as to the improvement of school administration and the introduction of economies in school finance. They talk in attractive generalities about the necessity of realistic training for citizenship and better community life. But it is rare that they ever become explicit as to what this actually involves with regard to curriculum content and the security of educational tenure. Even when entrusted with this task, educators are likely to prove something less than resolute. I was once a member of the committee which prepared the annual yearbook for the Department of Superintendence. It was entitled "The Improvement of Education for Democracy," and was dedicated to the memory of Horace Mann. It contained an extremely restrained statement of considerably less than the absolute minimum of realistic educational reforms necessary to make democracy workable. Yet it was denounced as radical and incendiary by leading educators, drawn from some of our most advanced schools of education.

Educators might just as well understand, once and for all, that we can not save democracy through education, unless we are willing to teach in our schools the materials which are essential to the salvation of democracy.

V

To sum up, we may say that American educators face two very definite and realistic alternatives. They can arouse themselves to the social responsibility of education, teach realistically and courageously those things which are essential to the preservation of democratic civilization, and organize themselves with sufficient coherence to make sure of their tenure while thus engaged. They may not succeed, if they literally shoulder the current social responsibilities of education, but at least they can go down fighting, having the satisfaction of knowing that they "kept the faith and fought a good fight," and that they did not abandon their ship while under fire.

If our educators refuse to take such steps while there is yet time, it is almost inevitable that some form of regimentation, roughly similar to European Fascism, will settle down upon us. Then, the condition of American educators will be unhappy indeed. Many will lose their positions, for, under Fascism, education is a much more simple and direct affair than under democracy. No such extensive and diversified personnel is required. Those who remain employed will be parrots in the classroom, and professionally a cross between "kicked dogs and scared rabbits." And this condition is not far off. When I was personally very familiar with Germany and the Germans a decade ago, Adolf Hitler was inconspicuous, even if compared with the current repute of our second-rate champions of Fascism. He was literally an unknown, when compared to the popular vogue of men like Father Coughlin to-day.

What I have written may be offensive to many. But I venture the guess that my remarks may appear more cogent and acceptable to such persons, in case they rub elbows with me in a concentration camp ten years hence. But then it will be a little too late.

CULTURE: A SCIENTIST'S IDEAL

By Dr. RONOLD KING

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FOR centuries men of letters, theologians and philosophers have thought and written in terms of those changing aspirations of an unfolding civilization that together form the history of the meaning of culture. For culture has had as many meanings as there have been minds that have speculated in a diversity of idealism so broad as to include both the crassest worldliness and the finest spirituality. Thus, on the one hand, the ideal of culture has been the glorification of man and the bold expression of all his hopes and wants; it has been the gratification of his senses, his quest for pleasure. Yet, on the other hand, culture has been the inspired exaltation of the supernatural and the sternest repression of desire; it has stood for the severest asceticism. Indeed, culture has ebbed and flowed like the ocean. It has whirled in the pleasure-bent eddies of hedonism; it has thundered the relentless dogma of religious fanatics; it has rippled gently in fresh breezes from Rousseau and Tolstoi; it has rested in limpid calm, reflecting Herder's vision of a higher nature and the intellectual freedom of Kant and of Fichte.

With the development of general education and the growth of scientific knowledge, the interpretation of culture became the province of the centers of learning. The German universities founded upon the principle of academic freedom and critical inquiry an ideal of scholarship which, in stressing creative thought, was destined to dazzle the world with its contributions to knowledge. In Britain grew that great tradition, the "liberal education" of Oxford and Cambridge, with its emphasis, following Plato, on "learning, morals, and manners." But the war and its consequences have left Europe staggering intellectually as well as morally; and there have arisen philosophers of despair who speak not merely of economic crisis and social upheaval, but, more significantly, of complete cultural decay. Thus, while on the European continent education has become merely a stern training in nationalism; in America it might almost be called an "activities racket." Thomas Huxley, in defining a liberal education, demanded that youth be trained so that it could work with ease and pleasure. But is not the work often forgotten in a philosophy of "painless education" which strives to make life a Walt Disney rhapsody in sugar-coated pills? Does not youthful laughter often echo with a blustering and ignorant conceit characteristic of languishing intellectual integrity? In this same spirit of self-deception culture has been defined to be "what is left after you have forgotten what you learned." And in the measure that dabbling aimlessly in many fields has become the approved process of learning, there is ever less and less to forget, and ever fewer find contentment in the mastery of even small things. In American colleges the liberal education of the English tradition and the scholarship of the German are often little else than travesties. Manners and morals are neglected, while learning is held synonymous with a graded superficiality that substitutes surveys and ready-made orientation for deeper knowledge. The ideal of general culture has, thus, degenerated into a peculiarly complacent pride in labelled mediocrity. Indeed, it has become like a swollen pie-crust that stretches a nicely browned and sugared surface over much hot air and a few berries lost in blue juice. Why bother about ideals when one can live? Why work when one can have fun? Can not the

practical mind be free and happy without the smugness of book-knowledge, without airs of refinement, without the stamp of a liberal education? But even the self-styled man of culture, blind to a historic tradition of adventurous thought, demands an idle place in the scientific sun. And while despising vocations, the mob, the labor problem and all machinery, he seeks consolation in the words of Powys:

> The cultured mind approaches everything through the imagination already charged with the passionate responses of the great artists; so that what he sees is a fragment of Nature double-dyed so to speak, a reach a stretch of time's whirling tide, that carries upon its chance-tossed eddies the pattern of something transitory and eternal.

While admiring the glitter of these mysterious words, those who are accustomed to view nature more intimately, more simply and less colored by wishful fancy see no whirling tide. For them the ocean of culture has ebbed to leave only brown mud-flats full of squirting clams and dotted with screeching gulls. White sails are furled; the clipper ships lie rotting. Will the tide ever run in again?

In seeking an answer to this question let us leave aside the passions of the great artists. Let us be impassionate and look at culture not only as a beautiful tradition, but as a hope of to-day for to-morrow. Perhaps, viewed more personally and more modestly, it need not be an impossible ideal; perhaps it can be more than a static state that old-fashioned people like to look back upon. True, it is difficult to forego that flourish of rhetoric, which to so many is the very essence of the idea of culture. And it may seem especially bitter to the artist actually to descend to earth to seek a tangible meaning for culture in the simple statement, "Culture is the working of the ground in order to raise crops."

Thus to define culture in terms of its most primitive origins is suggestive of agriculture, where the ground to be worked is the fertile but dusty earth; where the crops are just plants selected for a single vulgar characteristic—usefulness; where the work is hard and dirty—plowing, harrowing, seeding. But culture did not grow from a double-dyed fragment of a wave-tossed nature; it grew first from learning the meaning of usefulness, from distinguishing between weeds and valuable crops. It developed with intelligent and purposeful tools; it prospered with a slowly and painfully acquired knowledge of how to select seed from the more vigorous of the most useful plants.

Floriculture resembles agriculture in that it, too, grows plants in the earth, works over them with spade and hoe. But its aim is not usefulness. It seeks through patient and intelligent labor to develop flowers that will bring a special delight to him who approaches them, breathes their fragrance—the delight that men call the experience of beauty. Perhaps this form of culture will evoke the passionate responses of great artists, but fundamentally it is still agriculture, still the same working of the ground for a purpose, the same deliberate and studied attempt to control environment and understand heredity in order to find the satisfaction of greater usefulness, discover the joys of new beauty. And its success is not the result of indolent disinterest or careless superficiality, but of consistent learning from experience.

Self-culture is like agriculture and floriculture in ideal and in method, but it must work another ground with different tools and for a loftier purpose. In self-culture the ground is the conscious self with its environment of a living body and of the great physical world in which it moves. The crops are ideas charged with intrinsic worth; the work is the intelligent use and development of the tools of experience and knowledge; the method is that of science. The problem at hand is to examine the ground, this conscious self; to study the tools with which it may be worked; to think upon the crops, the

ideas, which may be raised. Is scientific self-culture possible? To what extent can an individual control his environment, coordinate his inherited talents and qualities to formulate and achieve his own ideal of worth?

The Ground

Whatever culture has been or may yet be, the immediate soil in which it grows is human personality. But an introspective awareness and a consciously analytical contemplation of self dawn only slowly upon the maturing human being. And what is eventually revealed in cognition is then inevitably and deeply colored by prejudice and habit. Thus, to venture to examine self first brings discovery and delight, then confused reluctance and increasing wonder. For across the threshold of the primary experience of self, of sense-perception, consciousness and cognition which unreels like a cinema upon happiness and pain, upon contentment and sorrow, is a startling and mysteriously complicated interplay of mental processes. There is memory which reenacts as upon a stage the nerve responses of the past. There is thought which combines and builds out of mere sensations stupendous edifices in abstraction. Such are beauty, truth and goodness: all patterns and sequences vaguely assembled by nerves stimulated by wave-trains originating in the physical world. Finally there is will, that seems to compel action according to an unknown scheme in a greater nature and which would yet offer conscious choice.

Surrounding and inseparably a part of this psychological world is a body composed of cells which grow and reproduce, which are strangely and powerfully linked with a dim past of untold ancestors. They are combined into a coordinated and integrated organism of complexly related, self-sustaining parts that are sensible to many and varied stimuli. These, in turn, lead to reactions in the form of sensation, of motion, of action and, after much repetition, of habit.

This entire biological-psychological structure is imbedded in an external environment of a social and physical world. Thus there are other human beings—parents, teachers, friends and foes. From them are acquired by persistent imitation, habits and prejudices and mental pictures in that scheme of custom and tradition which is society. There is the vast panorama of nature, of animals, plants and the inorganic; there is light for the eye, heat for the body, sound for the ear. And there are composite, man-made things—toys, machines, instruments for performing a million tasks; there are books containing mysterious treasures for the imagination.

It seems obvious that the conscious self, including its environment, is not simple to fathom or to analyze; yet some understanding must precede any attempt to control. For control is merely the ability to predict. To be sure, the study of human personality has always been the wonder of philosophers and the object of much detailed study by innumerable writers, seeking to portray the essential characteristics of their fellow men. And the literature of many lands is replete with character studies often revealing extraordinary and uncanny insight into human conduct as a problem of the coordination of an inherited nature with an uncontrolled and seemingly uncontrollable environment. Great as have been the contributions to the study of human nature of literary, historical and sacred writings, the information so presented is more interesting than it is exact; it is qualitative and general, rather than quantitatively specific. From it nothing may be predicted with certainty, for it attempts to give only a synthetic cross-section of types, not an analytical and functional study of individual personality as a part of a universe governed by natural law. It has been and continues to be the particular task of science

to pursue such a study. And scientific advance has been nothing short of phenomenal in some fields; in others little more than a beginning has been made. Thus the physical-chemical sciences have probed deep into the properties of inanimate matter with signal success in predicting and controlling its behavior. The physiological and biological sciences have studied the characteristics of life processes, of evolution and of inheritance. While learning much that is of the most fundamental significance, they have as yet not penetrated into the mysteries of the auto-synthetic and auto-attractive properties of the ultimate particles of life, the genes. Psychologists, anthropologists and sociologists have struggled manfully with the extremely complex psycho-physical make-up or personality of individuals and of groups. By many approaches they have sought to disclose some of the deeper secrets of consciousness and of mental processes. But their task is hardly begun. And each individual, interested in a practical scheme of living, finds even the most modern science able to contribute little more than an optimistic attitude instead of essential knowledge about mind and body as a functioning unit in a personality-moulding environment. Inevitably he senses that mankind is pathetically ignorant, and he wonders whether the whole idea of scientific self-culture is not premature, whether mysticism in one form or another is not to be preferred. For it is still extremely difficult for even a keen intellect to view himself as a part of a natural order subject to natural law. It seems reasonable enough for the physicist, the chemist, or even the geneticist to control certain forces of nature or at least predict their behavior from mathematical formulae. But to picture himself as consciously and deliberately planning his own road to what is worth while startles him, even frightens him into believing that there is greater hope and comfort in the passive faith of ignorance.

Tools

Each human personality, when it attains the maturity which finds interest in the problems of self-culture, is the product of a complicated sequence of interactions depending upon heredity and environment during those formative years over which the individual had no control whatever. What he does and thinks to-day is thus indeed the outcome of all his yesterdays. But is not that a key to the future? Personality does not change abruptly; but must not its development be deeply influenced by always seeing each to-day as a yesterday for to-morrow? Can it not be encouraged to grow more like wheat in straight furrows planted to-day, instead of like weeds scattered by the winds of habitless chance? The answer lies with the individual sensibility to experience and knowledge, with the tools of self-culture; and with the hand that must guide them, with intelligence.

The basis of experience is perception. This does not depend only upon immediate sensation, but also upon images in memory and, in particular, upon that mental activity which discriminates and recognizes. Thus, although it be not possible for an individual to predetermine his environment in any general sense, he can certainly deliberately set out to observe some things with attention, to pass others by completely or superficially. He can not always select what he wishes to forget, and then forget it; but he may well choose what he will remember, and make that the food for his thoughts. And thinking, he may reject one subject in order to dwell more deeply on another. In this way he may exercise intelligent selection in the development of intellectual as well as physical habits and taste. Experience, in brief, is a tool which moulds personality. It has its special characteristics and, of course, its limitations. Like every other tool it can be used and misused. It can be handled expertly and with grace, or clumsily and

without care. Each man must use it, whether he will or no. But only a few try to learn its secrets in an attempt to develop a technique for using it effectively in the practice of self-culture.

Knowledge is a special kind of experience. It is the history largely of other people's discoveries translated into the language of one's own thoughts. It is a master tool with which one may learn to use immediate experience to greater advantage. With it thoughts may be developed and guided; memory may be stocked; perception itself may be enlarged to include a new freedom acquired only through knowledge of natural law in the broadest sense. For when there is consonance between man's habits of thinking and willing and an observed consistency in nature, the experience of freedom is boundless. It is the aim of science to achieve this freedom by discovering processes of thought which express the consistency or permanence actually observed in nature in a general and useful form. Hence, if the ideal of self-culture is still the old "Know thyself," its meaning may be made scientific. For to have formulated the laws of nature, is to have found the key to harmony in life and to the discovery of what is preeminently worth while.

Without intelligence experience is wasted and there can be no knowledge. A man's intelligence is a part of his inheritance; it is a link in the evolution of the human species. To possess intelligence is to be capable of learning to guide the tools of experience and knowledge in the interest of self-culture. Few habitually take advantage of this faculty to develop technique and to build new habits of skill; many let it wither and die.

To work the ground in self-culture is far more difficult than in agriculture, for the seeds of worth-while ideas have never been discovered. Fortunately, thanks to keen observers, a little is known about the conditions most favorable to their appearance as if from nowhere. And each individual can learn much about his own personality by careful observation and judicious experiment. The great mathematician, Poincaré, has given a formula for his own case, and many a scientist has learned its value. Poincaré discovered that while new and significant ideas grew most readily when his mind had been deeply saturated with a subject, they ripened to maturity more often in the clear air of complete distraction. Thus, to work the ground truly is to study deeply, to use experience and knowledge with a maximum of skill. And then, when all may seem to have been in vain, to relax, to forcibly hurl consciousness into the refreshing environment of wholesome pleasure. Then, if the preparation has indeed been adequate, ideas may begin to appear as if by magic, thoughts gather, and the ecstasy of creation and discovery will fill the whole being with its dazzling light. Presently it will grow dim, and the time will have come for weeding and systematic cultivation. The new thoughts must be examined critically; they must be studied on the basis of experience, analyzed in the cold gleam of objective knowledge. What is unworthy may then be rejected; what seems truly worth-while must be retained, developed, allowed to take root and grow into new habits, for that is the ideal of self-culture. In the words of Goethe: "Eine schiefe eigene Meinung bringt der Erkenntnis naeher als eine uebernommene richtige."

The Crops

In agriculture one seeks useful plants; in floriculture those characterized by beauty. In self-culture the purpose is to develop ideas charged with worth. But what is this usefulness? What is beauty? More particularly, what constitutes worth? These are all abstract and relative terms signifying certain groups of nerve-cell reactions characterized in a recognizable and distinctive way by each individual sensibility. Thus, there are

experiences which produce the sensation called beauty; there are others that lead to that called usefulness; and both may be included in a single, more general group as characterizing two aspects of worth, meaning desirability. And what will or will not be so grouped depends in the last analysis on each personality. In general, however, there is wide-spread agreement on many experiences leading to individual sensations called beauty or usefulness. In agriculture, then, worth-while means useful; in floriculture it means beautiful; in self-culture, on the other hand, it seems convenient to distinguish four broad and overlapping sensation-groups which may be called the qualities of worth. They are, first, the essential quality of usefulness; second, the esthetic quality of beauty; third, the rational quality of truth; fourth, the moral quality of goodness. Of these four qualities the first two, emphasizing things to be done or achieved, are essentially artistic in nature. They may be associated, respectively, with the practical and the fine arts. The last two qualities, on the other hand, concern themselves principally with method and with knowledge. They are thus scientific in nature, and are related, respectively, to the natural sciences, mathematics and logic in the first, and to ethical science in the second. To understand worth, then, as the characteristic ideal of self-culture, means to have broad experience in these four qualities. In themselves they critically encompass all human experience and knowledge; they suggest many fields as yet hardly touched.

The quality of usefulness is associated with practical things. In a restricted sense it means the fulfilment of essential wants which, in the modern picture, include food, clothing, shelter and comfort. But in a larger sense much of human civilization is an expression of usefulness. For its professions, trades and practical arts; its instruments of government and law, of education, of commerce and of industry are dedicated to the end of service. It is in this broad and comprehensive sense that usefulness is described as the essential quality of worth. It is the foundation of life in a society; it is prerequisite to physical and mental living. But usefulness is not synonymous with worth; it is but one of its qualities. And that utilitarianism which would make utility the only significant characteristic of genuine worth is either still buried in the primitive past of a stone age, or it has descended to the insipid comfortism of to-day. What is useful to man and society must always be preeminently worth while, for it includes all that is related to the direct control of experience. But a broader vision of an enlightened self-culture will seek and find values transcending far that of usefulness alone in its plan of creative achievement.

The esthetic quality is derived from primitive responses to pleasure. But in an integrated and highly organized social structure with its problem of human relationship, pleasure is a complex experience associated not only with direct sensation, but also with cognitive sequences and coordinations. Beauty is, thus, an experience not only of physical pleasure, but more especially of emotional and intellectual enjoyment. Beauty in physical things, for example, is characterized by color, shape and proportion; beauty in literature depends upon style, diction and motivation; beauty in science involves simplicity of structure, clarity and coordinated symmetry; beauty in human relationships is associated with fairness, loyalty, unselfishness and cultivation. But always beauty is a personal discovery, and as such it is essentially relative. Its definition by an individual depends alike upon his refinement in sensibility and upon his breadth of experience; its perception is intimately related to his manner of approach, to his attitude toward problems of self and society. Just as there are modern utilitarians who

dogmatically identify worth with utility, so there are the old aristocrats of culture that like to associate it exclusively with beauty. More significantly, culture from their point of view is not a conscious striving for a purpose, but rather a fait accompli, a static condition of conventional form in manner and of traditional point of view. Even as the utilitarian is emotionally in a stone age of food, clothing and shelter, so these white-collared gentlemen of etiquette are intellectually still in the Victorian age of belles-lettres. Beauty as a quality of worth must burst such corsetted dogmatism if it is to lead in a modern quest for self-culture.

The experience of truth is the climax in the exercise of reason. It is a cognitive reaction so unique and characterized by an intellectual exhilaration so unmistakable that there is strong temptation on the part of those who know it well to elevate it to a favored place among the qualities of worth. In meaning, truth is not rigid and static, as many would have it; it is no unchanging principle of an eternal universe. But rather, it is relative, like beauty; like usefulness it depends upon the time in history, upon circumstance and especially upon the sensibility of the individual who perceives it. For truth is continually being made and modified by experience. A new truth is accepted and an old one is rejected as a mistake if the cognitive processes are so better served. To be sure, it is at times pleasing and impressive to maintain that truth exists continuously though unknown, floating vaguely in an abstract universe as an absolute and unknowable ideal. But in the language of science such evidences of lofty desire serve no useful purpose; for each scientific observer, truth must be primarily the claim of a particular moment and place in his cognitive experience. And the personality of each individual unmistakably reveals itself in the postulates he sets up as true and in the evidence which he accepts as convincing test. The scientist attempts to establish the truth of a hypothesis by the systematic observation of its consequences in a planned and controlled experiment. The religious thinker, proceeding in a fundamentally similar method of also seeking verification for beliefs and doctrines, often depends upon experiences so deeply and unalterably colored by faith in the very postulates he seeks to verify that the test loses all meaning. Science, too, has faith, but it is not faith in postulates. It is faith in a method for defining truth specifically in terms of directly observable consequences. Thus, by establishing a correspondence between abstract mathematical thought and direct experimental observation upon periodicity in natural phenomena, the mathematical-scientific method was developed as a means of defining truth in terms of a predictable consistency in nature. In this way qualitative understanding was augmented by quantitative knowledge; a vague and imaginative ideal of truth was elevated in science to a well-defined intellectual experience. In other fields of human activity the meaning of truth is still often associated with man's ignorance rather than with his knowledge, however limited that may be. Such an irrational worship of vagueness has nothing in common with truth as a fundamental rational quality of real worth, as a cognitive experience that reveals harmony and order in the mind's description of nature in the broadest and most inclusive sense.

The moral quality of goodness has not been illuminated by a development of ethical science comparable with the phenomenal advance in natural science. But, as in the case of truth, the meaning of goodness at any time and place depends upon its observed consequences as interpreted and accepted by each individual himself. Thus the mystic is inclined to seek evidence as to consequences in terms of personal intuition which he believes to be either directly inspired by the supernatural or indirectly revealed in sacred

writings and customs. The realist, on the other hand, establishes more worldly tests in the form of rational and practical codes of ethics built upon direct observation and adjusted more or less successfully to the needs and exigencies of the time and place. Finally, many another projects human ignorance into infinite spaces of thought, calls it God or Virtue, and worships it blindly or fearfully as the ideal of combined truth and goodness. For such a devout the very quest for self-culture must be heresy. Thus one is led to wonder with Malisoff, "whether the truer prayer occurs before a shrine or before a magnificent illumination of human intellect." As a quality of the ideal of worth, as a characteristic of the very purpose of self-culture, goodness must belong to the human intellect as the guiding inspiration of a yet undeveloped ethical science. As a recognized and valued experience it must join in synthesis and harmony the qualities of usefulness, beauty and truth. For what is truly worth-while must have a consistent meaning in the mind of each worker in self-culture. It must encompass his most valued experiences in memory, his loftiest ideals in imagination; and both must rise from the still small foundation of scientific knowledge. Worth, so qualified, is to characterize the crops of self-culture, those ideas grown in the soil of consciousness by an intelligence guiding the tools of experience and knowledge.

The Ideal

In the furrows of the earth is written a meaning of culture that is as lofty in its idealism, as naïve in its simple faith and as uncompromising in its tireless industry as science itself. It is a dynamic reality, not a static memory. It demands creative effort, not merely a languishing veneration of a beautiful past. It is measured not by the elegance of a man's language or attire, not by what he has forgotten or still remembers, not by passionate responses inspired by great artists, but by his own ambition, by his own attitude toward his to-morrow. It builds upon intelligence, upon the skill and experience of to-day and the wisdom and knowledge of yesterday a plan for enthusiastic, vigorous creation. Scientific self-culture is still a hope rather than a completely realized method, but as such it is a true guide for him who labors with facts against prejudices, who walks modestly but courageously and confidently toward high places. Culture is a quest for vision and understanding; it is planful living. Culture is the working of the ground in order to raise crops; it is the conditioning of the conscious self to understand and to create what is worth while.

Let there be a regeneration of such an ideal of culture, and it will bring with it learning, morals and manners. For it is an ideal of self-respect and of planned achievement, that grows not on those broad vistas of sand swept by the changing whims of educational fancy, but in the fertile valleys of individual experience, in the deep channels of personal knowledge. Let those who would be cultured seek more than a shell of form; let them be inspired by the will and the intellectual freedom that grows from profound understanding and consummate skill; let them study the technique of planned living; let them seek what is truly worth while in all things as usefulness, as beauty, as truth and as goodness. Then they may thrill to the wonder of creation and discovery, and so become conscious partners in the unfolding of civilization. All culture ebbs and flows with self-culture. Over the mud of intellectual indolence and spouting superficiality must rise the relentless tide of scientific truth. Then, over deep blue waters the white sails of trained and enthusiastic intellects may strain before an ever-fresh wind from the Great Unknown.

AMERICA'S CHEMICAL HERITAGE

By Professor HARRISON HALE
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NOT every American chemist, busily engaged in his daily tasks, realizes the heritage that is rightfully his. From the very earliest days of the white man's life in America chemistry has been a factor in this country's growth and development. Since the World War its increasing importance has commanded the attention and respect of every American who thinks. America's chemical heritage includes this record of past achievement, present-day accomplishment and hope for the future. To present this satisfactorily one must of necessity rival the speed of the lamb, which, it was claimed, could run sixty miles an hour, since only at this rate could the lamb keep up with Mary to-day.

In the opening sentences of his "Histoire des Doctrines Chimiques," Wurtz wrote: "Chemistry is a French science. It was founded by Lavoisier of immortal memory and its most lasting contributions have been made by his countrymen." Naturally such a statement was a basis of angry controversy and dispute. This was more than half a century ago. Only a few years ago Philipp Lenard, Nobel Prize winner in physics, published the first volume of his "Deutsche Physik," dedicated to the German Minister of the Interior. In it the statement that "Science is and remains international" is declared to be false. And Lenard was awarded the Franklin Medal in 1932 in recognition of a "life work devoted to fruitful research in physics."

Johannes Stark, also Nobel Prize winner in physics, takes the same position in an article on "The Pragmatic and the Dogmatic Spirit in Physics" published in the British journal, *Nature,* in 1938, making an attack upon the Jews. More than 1,200 American scientists registered a vigorous objection. Not in any spirit similar either to that of the Frenchman or of the German is America's chemical heritage presented.

Rather do we agree with the position taken by another German, Nobel Prize winner in chemistry, as stated in his "Die Forderung des Tages," published in 1910. Here Wilhelm Ostwald declares, "Of the things that mankind possesses in common, nothing is so truly universal and international as science." In chemistry as in other fields of endeavor, we in the United States owe very much to the other countries, not only for ideas, but for men who have helped in the development of these ideas. Surely science should transcend nationalism, for science is founded upon truth, which knows no national boundaries.

Yet America does have a chemical history and heritage well worth knowing. In his "Novum Organum," Francis Bacon (1561–1626) said, "The true and lawful goal of the sciences is none other than this: That human life be endowed with new discoveries and power." When we recall that about the time this was written the early permanent settlements in America were being made, the statement seems prophetic of the developments and achievements to be made by chemistry in this new land. From Charles A. Browne, a foremost authority on American chemical history, we learn: "The London Company, the year after they founded the Jamestown settlement, sent eight Poles and Germans to the new colony to make pitch, tar, glass, and soapashes. No sooner had these workmen landed than they began operations. From this small beginning in 1608 we now date

the commencement of chemical industries in America." These products were among the earliest of American exports.

Expansion of chemical industries was even then in evidence, for 150 men were sent out in 1620 to set up three iron works. Salt works to supply the Atlantic coast fisheries were established, and lead smelting was progressing. But, "all industrial efforts were paralyzed by the Indian War of 1622."

In April, 1935, in New York City, the American Chemical Society held its largest meeting with a group claimed to be the greatest gathering of chemists ever assembled, but not necessarily the gathering of the greatest chemists. The 300th anniversary of the work of John Winthrop, Jr., in industrial chemistry in America was celebrated. Winthrop actually had a laboratory and a library in the Colony of Massachusetts and made chemical tests. He projected the manufacture of salt, saltpeter, pine-tar, glass, potash, iron, copper, alum, gunpowder, medicines—a rather ambitious program. He actually produced only the first three. Of his library, 270 volumes have been preserved, some of which were exhibited at the New York meeting. Some one has said, "Chemistry is a young science but an ancient art." At Jamestown there was the art of chemistry, in New England the beginning of the scientific side. From these early beginnings, sometimes aided by outward circumstances and sometimes hindered, chemistry in America has steadily grown until it occupies a preeminent place and gives still greater promise for the future. As the Irish say, its advance has been steady by jerks.

Not only is this true of material development, but it is true of the intellectual and theoretical side, because it is obviously necessary that the two must go hand in hand. To change the simile, if chemistry progresses upon the two legs of industry and research, then it is necessary that each of these must develop equally unless its progress is to be grotesque. The United States, with approximately 6 per cent. of the world's population, has a chemical production approaching 60 per cent. of the world's total. It is not yet so high and may not reach this figure, but it was placed at 47 per cent. in 1927 by an authoritative German source, and there has been much progress since then.

Modern chemistry is sometimes dated from the discovery of oxygen by the Englishman, Joseph Priestley, in 1774. Twenty years after this discovery Priestley came to Pennsylvania. Here he lived for the last ten years of his life and there in Northumberland his grave is to-day, a constant reminder of the inspiration which he brought. Priestley's discovery would have lost much of its significance had it not been interpreted by Lavoisier and its importance shown. It is most interesting that the founder of the du Pont Company learned the art and the science of powder-making from this distinguished Frenchman.

In *The American Chemist* for April, 1874, Dr. H. C. Bolton, of Columbia College, called attention to the importance of 1774 in chemical history, stating that "the year may well be considered as the starting point of modern chemistry." Note was made of the discovery of oxygen by Priestley, "the immediate results of which were the overthrow of the time-honored phlogistic theory and the foundation of chemistry on its present basis." Dr. Bolton suggested a centennial celebration on August 1. This suggestion was endorsed by the editors, who asked interested chemists to "send their views at once so that the project could be put into practical form in time. In response Miss Rachel L. Bodley, professor of chemistry in the Woman's Medical College of Pennsylvania, suggested Northumberland as the most appropriate place. A call for a two-day meeting, be-

ginning on July 31, was issued and seventy-seven chemists met. They elected one president, Charles F. Chandler, of the School of Mines, Columbia University, and thirteen vice-presidents. At this meeting the organization of a chemical society was discussed, but no action was taken in deference to plans for "establishing a chemical section" of the American Association for the Advancement of Science. The idea, however, was not dead and the American Chemical Society with 133 members came into being in New York City in April, 1876. What it has become in the past sixty-two years is worth our knowing.

To give the history of this, the largest of the chemical societies, in any adequate form would take far too much time. From the beginning women have been admitted upon the same terms as men; at no time has there been any distinction because of sex or of sectionalism. Its first president was from New York and its second from Virginia. It is an unusual privilege that is offered to American chemists to become members of this society, which has done so much for chemistry. Its publications far surpass those of foreign chemical societies in the amount produced and in the low cost for which they may be obtained. Dr. Harrison E. Howe states that "to read aloud, word for word, at reasonable speed, the material which is published annually by the American Chemical Society alone, exclusive of *Chemical Abstracts,* would require a thousand hours." On the basis of the forty-hour week this is practically half of the year, and we have made no mention of other chemical publications, both American and foreign.

To meet this situation there is the publication of the society, *Chemical Abstracts.* In it there is not only a convenient record in duly classified form of all chemical work published in approximately 3,000 journals from all over the world, but there is evidence of thought, care and devotion on the part of its editor and fellow workers that make it a constant inspiration. I doubt if any living man is giving to chemistry more efficient and important service than Evan J. Crane. *Chemical Abstracts* is now in its thirty-fourth year, and when the current volume is compared in size with that of 1906, one wonders what will be the result in 1966 or 76, the centennial year of the society. The stream of publications is becoming so mighty that it threatens to engulf us. We are reminded that Egypt came to its decline when its libraries were filled. But we know also that Egypt had no system of organization for the use of this knowledge such as that which *Chemical Abstracts* furnishes. The curve in Fig. 1 shows the

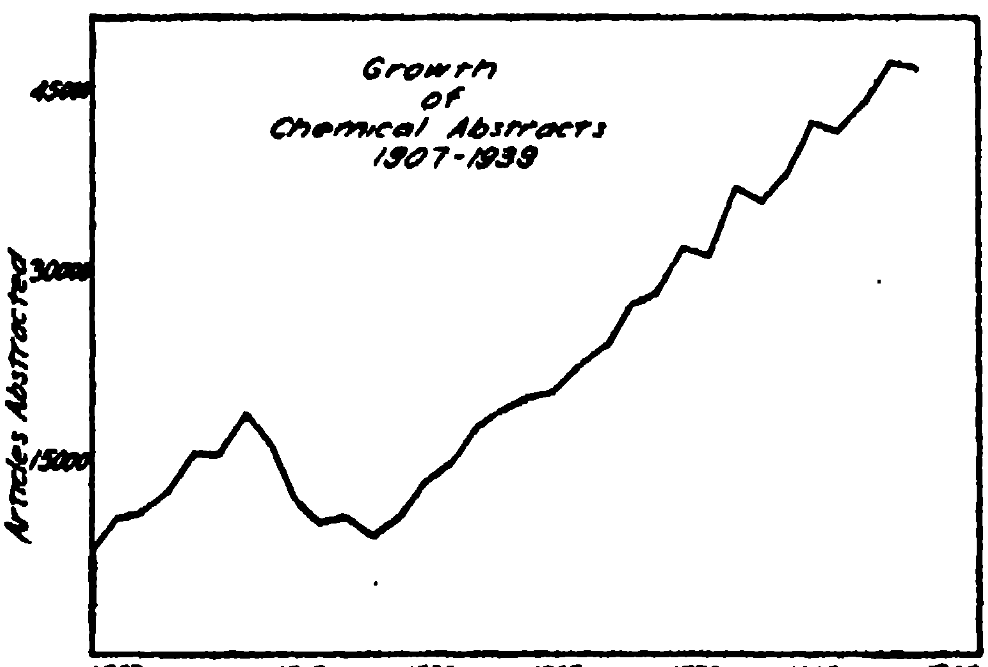


FIG. 1

number of articles abstracted each year, omitting patents. For compactness with exactness and completeness there is much to be said for the place of the biblio-film in the future.

Most interesting in connection with the American Chemical Society have been the men who have served as president. Studying this noteworthy group has been an inspiration. Almost without exception they possess a wonderful capacity for work, and this work lies in widely different fields—from that of practical usefulness to abstruse theory, from the invention of the ink used to print greenback currency and of the flush water-closet (left unpatented that its general

use might bring an improvement in sanitary conditions) to outstanding studies on atomic weights, on the structure of the atom and of the most complex compounds.

It has been a prolific group chemically, the published papers being estimated at five thousand, and the books, usually on chemistry but some on a wide variety of subjects, at several hundred. These presidents include the "chemist of the Southern Confederacy" as well as an assistant surgeon in the Union Army and another Union soldier who was wounded. Nearly a dozen were actively engaged in the World War. In Table 1 are shown their place of birth, residence while president and occupation.

TABLE 1

PRESIDENTS, AMERICAN CHEMICAL SOCIETY, 1876–1941

Place of Birth	
Great Britain	3
Germany	2
Belgium, Canada, Russia—each	1
Massachusetts	11
New York	9
Pennsylvania	4
New Jersey, Ohio—each	3
Connecticut, Kansas, Maryland—each	2
Georgia, Hawaii, Illinois, Iowa, Indiana, Rhode Island, South Carolina, Tennessee, Virginia—each	1
Total	53
Residence	
New York	10
Massachusetts, Pennsylvania—each	8
Illinois	7
District of Columbia	4
Ohio	3
Michigan, North Carolina—each	2
California, Connecticut, Delaware, Iowa, Kentucky, Maryland, Minnesota, New Jersey, Virginia—each	1
Total	53
Occupation	
Teacher	38
Commercial laboratory	4
Industrial research	4
Manufacturing chemist	4
Government chemist	3
Total	53

Not only does America have the largest chemical society, but apparently it had the first—The Chemical Society of Philadelphia—founded by James Woodhouse in 1792. James Kendall claims there was a chemical society in Scotland a few years older, but this seems to have been chiefly a student group at the University of Edinburgh. This American society was active for seventeen yaers, having a decided influence upon the chemical thought of its day and leaving some interesting papers. In an address delivered before this society on April 11, 1798, Thomas P. Smith makes suggestions which are as vital and timely today as they were more than a century ago. He says: "The only true bases upon which the independence of our country can rest are agriculture and manufactures. To the promotion of these nothing tends in a higher degree

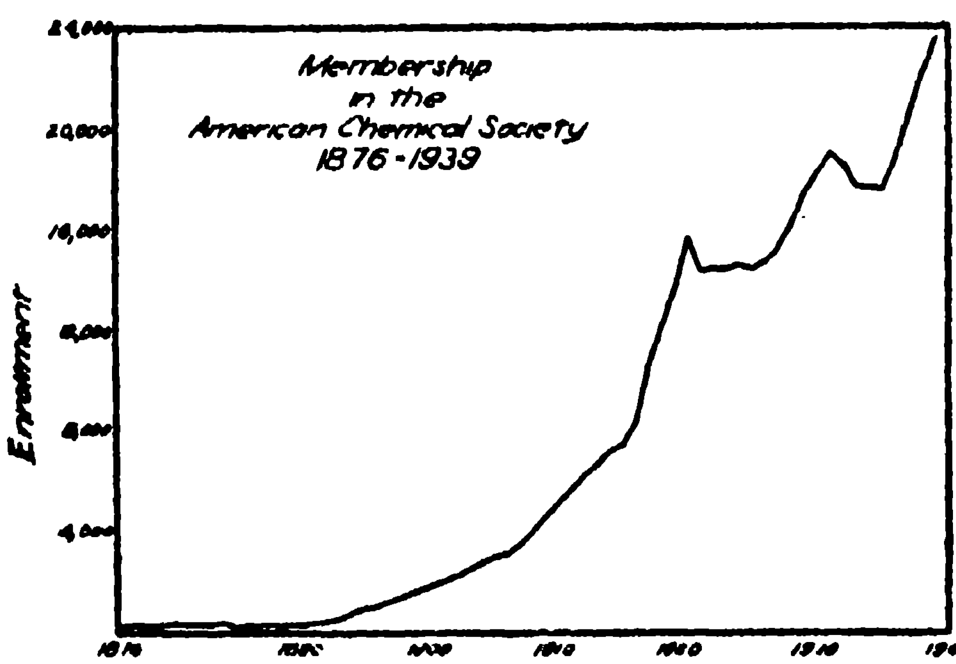


FIG. 2

than chemistry. . . . It is to a general diffusion of a knowledge of this science, next to the virtue of our countrymen, that we are to look for the firm establishment of our independence."

The growth in membership of the American Chemical Society is seen in the curve in Fig. 2. The effects of the World War and of depressions are evident. It is noteworthy that for years the society was not much more than a local New York organization, all the meetings being held in New York City. The membership in 1889 was 204, compared with 230 at the end of the first year. General Meetings, not necessarily in New York, were arranged, the first being held in Newport, R. I., and the

second in Philadelphia, both in 1890. The first local section, that of Rhode Island, was authorized in 1891. During the third general meeting in Washington in August, 1891, a conference of delegates from chemical societies from various sections was held, satisfactory plans were adopted and the growth of the society began again. The incorporation effected in January, 1938, with a national charter approved by act of Congress, August 25, 1937, symbolizes the nationwide influence of our society.

In a paper entitled "Chemical Societies in the XIX Century," presented at the twenty-fifth anniversary of the society in New York in April, 1901, Henry Carrington Bolton lists 66 such societies and gives their total membership by countries. The total of the seven in the United States ranks fifth, being less than that of Great Britain, Germany, France or Austria. The American Chemical Society in 1900 had twelve sections, only one being in the South and one west of the Mississippi River. Its membership is given as 1,679.

TABLE 2

CHEMICAL SOCIETIES OF THE WORLD (AFTER H. C. BOLTON—1900)

	Societies	Members
Great Britain	10	7,750
Germany	15	7,431
France	11	4,077
Austria	8	2,972
U. S. A.	7	2,575
Japan	2	1,012
Others—7—	13	1,973
Totals	66	27,790

So many phases of our chemical heritage now in evidence might be mentioned that there must of necessity be a selection. Reference will be made only to the development of men and women in chemistry and to the productive chemical capacity of our nation.

The contact of one personality with another has always interested me. This interest was deepened by my good fortune in being a student at the University of Pennsylvania, under Dr. Edgar F. Smith, who in his turn had been greatly inspired as a young man while working under the direction of the elderly Wohler at Göttingen in Germany. If properly catalyzed by student questions, Dr. Smith would talk most entertainingly by the hour of his experiences with Wohler and I think it quite possible we learned more in that way than we might have learned by the regular lesson. Wohler was a student of the great Berzelius in Sweden, who frankly acknowledged that he was the last man who would ever know all of chemistry! For many years Berzelius's word in chemical matters was accepted practically without question. I like to tell my students, then, of their illustrious chemical ancestry in Grandfather Smith, Great-grandfather Wohler and Great-great-grandfather Berzelius.

The influence of this German and of this Swede and of other European teachers has been transmitted by their students and has become as real a part of our American chemical heritage as the Swedish heritage celebrated in Wilmington in 1938. Dr. Smith enjoyed arguing that Wohler had had the greatest influence upon chemistry of any man in America, furnishing as one basis of proof that Wohler had trained many who later became presidents of the American Chemical Society. No doubt a student of Bunsen or of others could furnish contrary arguments equally convincing to him. Certain it is that America owes very much to Europe and most of all to Germany for the early days of its chemical heritage. A chemist can notice on his society pin or button the potash bulb of Liebig, or observe the shape of your Alpha Chi Sigma badge, your Phi Lambda Upsilon key or the insignia of the Chemical Warfare Service, the hexagon of Kekulé. Both Liebig and Kekulé were born in Germany early in the nineteenth century and lived and worked there. In using the words "our society"

I have been reminded of how chemists of the generations before us often spoke of "*our science.*"

It is worthy of note, however, that in accordance with American tradition we have not simply borrowed blindly from Germany, but that we have developed on this soil along every line the ideas germinated there, often enriching and extending them. The chairman of the International Committee of Atomic Weights for many years was Professor Theodore William Richards of Harvard, first American winner of the Nobel Prize in chemistry. To-day one of his pupils at Harvard has succeeded him as chairman, and the German representative on this committee is also a former student of Richards. German chemists are rightfully entitled to much credit for the development of the coal-tar industry and the production from it of dyes, medicines, perfumes, explosives and flavoring materials. During and since the World War American chemists have been making a similar achievement with the typically American products, petroleum and cotton, and in many other fields.

Recently I visited the du Pont alcohol plant in Deepwater under the guidance of an old friend, an alumnus of the University of Arkansas. Not only was I impressed with the appearance and efficiency of this plant, but in looking from the windows of the fermentation building I could see where ethyl fluid was made and was shown the location for the work done on many chemical compounds that later led to industrial triumphs. And I felt that here surely is a place typical of the spirit of American chemistry.

In Tulsa at the meeting of the American Chemical Society in April, 1926, preparatory to its semi-centennial celebration that fall, a dozen outstanding world chemists were elected to honorary membership. Apparently no great difficulty was experienced in selecting the three Americans upon whom this honor was bestowed. Richards of Harvard, Remsen of Hopkins and Smith of Pennsylvania were so clearly preeminent that the choice was relatively easy. Now, only fourteen years later, it would actually be impossible to select with ease the three outstanding chemists of America. The three men chosen in 1926 passed within a few years to their reward, but there have been none since then who have reached a position similar to that held by them. Great as these men were and as much as I admire them, I do not feel that we shall never see their like again. Rather do I think that due in

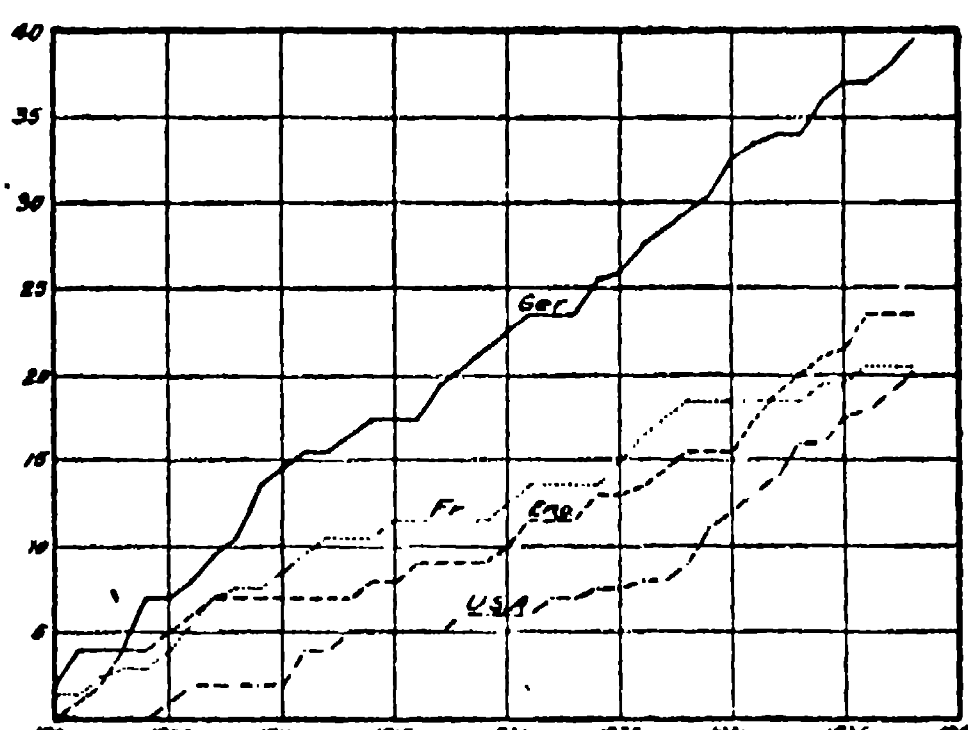


FIG. 3

large measure to their influence and that of their contemporaries, America has developed so many men of ability and power that the entire chemical level has been raised and hence no one is now likely to attain such marked preeminence.

In the winning of Nobel Prizes in science during the 39 years since the awards began, the success of Germany has been noteworthy, as seen in this table and this graph. (Fig. 3).

Of the thirty-four prizes in chemistry only three have come to the United States, the winners being Richards, Langmuir and Urey. England and France have received more and Germany many more. (See Table 3.) However, two of the three have been received

TABLE 3

NOBEL PRIZE WINNERS IN CHEMISTRY, 1901–1939

Germany	15.5
England	5
France	4
U. S. A.	3
Sweden	2.5
Switzerland	2.0
Holland	1
Austria	1
Total	34

within the last eight years and the future holds much of promise. It seems to me that the younger chemists now coming to maturity are not only maintaining, but are actually advancing the standards set by former American chemists. My experience in securing additional members of my department and as a member for three years of the committee of the society responsible for the A. C. Langmuir and the James Kendall awards is the basis of this statement.

The increase in the number of students in chemistry and in the laboratories for their training indicates no shortage of applicants for chemical work. Quantity will not be lacking, but quality is more significant. Some ten years ago 77 out of 78 chemical manufacturers who replied to a questionnaire said that better chemists rather than more chemists were needed. This is at once a challenge both to students and to teachers. It is just as much the duty of any good department of chemistry to keep out the unfit as it is to train the capable. To know just what to teach is difficult. Recently my colleagues have been asking for more time for organic chemistry and for physical chemistry, and they need it. But the capacity of the average student has not greatly increased, and there can be no additions to a four-year curriculum, only substitutions—and what can be omitted? What must be left for graduate study? Cooperation and understanding between industrialists and teachers in the training of chemists are necessary. Here again our society aids. At the Pittsburgh meeting an entire session of the Division of Chemical Education was used for discussing the question, "What Industry Wants of Its Chemists." Outstanding leaders in industrial chemistry, one from Wilmington, made the answer. Even more effective are countless personal contacts between chemists in industry and in teaching. This is one reason I value so highly your invitation.

The increasing number of students in chemical engineering is impressive. The American Institute of Chemical Engineers is not quite half as old as the American Chemical Society. Membership in the institute has been restricted. Its rapid recent growth is shown in Fig. 4. That a recent report shows 2,278

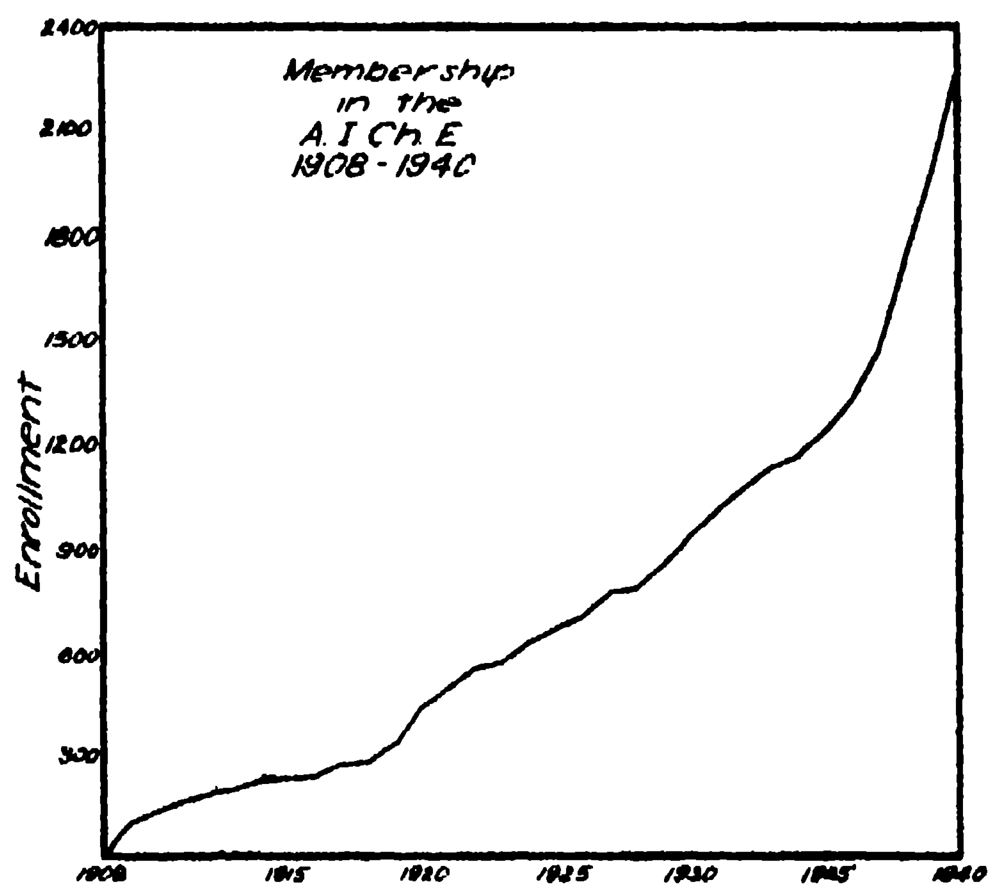


FIG. 4

members of all classes in the parent organization and of 5,000 members in 69 student branches makes one wonder.

Figures given by Professor Alfred H. White before the International Chemical Engineering Congress in London show that the number of undergraduates in engineering in the United States has increased about three times from 1910 to 1935. The number of undergraduates in chemical engineering has increased during this same period more than twelve times. The percentage of students working toward the doctorate among

chemical engineers is far higher than that in any other engineering group.

So much for men and women in chemistry in America; just a word of the material side. In his book on "Men, Money and Molecules," Williams Haynes states that, "In the United States we make more chemicals—measured either in tons or in dollars—than are produced in Germany, England, France, Italy, Japan and Russia, all added together." It is not surprising then to have him remark that, "If the coming era is to be a chemical age in industry, there is every reason for America to be optimistic." We recognize that this is due in part to our natural resources, but it is the result also of an energetic use of these resources. If our position is to be maintained, research on an increasing scale must be continued. This area has set a splendid example in such work. We are hopeful of results of value from the new government laboratories for research on the use of agricultural products. These results will come if the work in them even approaches that done in the Bureau of Standards and certain other state and federal laboratories.

Herbert Hoover has said: "No human person can evaluate the contribution of the science of chemistry to the advancement of civilization. The enormous advance in standards of living, the greater margins of comfort, the lessening of physical exertion required to attain these things, the relief of suffering, the extension of health and life, have all received the most vital contribution by the applied science of chemistry."

Each American chemist has the right to pride and satisfaction in his work, to look forward eagerly to the future and to the difficult task of continued service to the nation and to the world. We see that in American chemistry that has been, is and is to be, there is much of challenge, of inspiration and of hope.

GEOMETRY: THE KEY OF THE SCIENCES

Geometry, to which I have devoted my life, is honored with the title of the Key of the Sciences, . . .

The key! It is of wonderful construction, with its infinity of combination and its unlimited capacity to fit every lock, however varied in form and size, . . .

Begin with the heavens themselves; see how precisely the motions of the firmament have endured through the friction of the ages; observe the exactness of the revolutions of the stars; if these mighty orbs can not resist the law, what can the atom do? Let, then, the resources of art be exhausted in this scrutiny. Let neither time nor labor nor money be spared. A slight defect of motion is just detected; it is slight, very slight, but it is unquestionable. We dare not hide it out of sight. Science must admit this triumph of art and be true even if the stars are false. The names of fixed star and pole-star must not be suffered to impose upon the trusting world, and guide it in a delusive chase after an *ignis fatuus*. Geometry! to the rescue! Geometry is at her post, faithful among the faithless. The pen is at work, the midnight oil consumed, the magic circles drawn by the wise men of the East, and the wizard logarithm summoned from the North. The tables are turned. The defect of motion is transformed into the discovery of a new law. It becomes the proof of the atmosphere to bend the ray from its course as it shoots down, laden with the image of Arcturus and the sweet influences of the Pleiades; it becomes the proof of the moving light, of the unseen planet, and of the invisible star, and hence a new proof of the precision of the measure. Honor to Bradley, to Bessel, to Adams and to Leverrier! The stars are not false. Question them as you may, they give the same evidence and do not contradict each other's testimony. They tell us that ours is not the central sun, and that we are moving in the procession of the stars; they tell us that we move among the others, towards the constellation of Hercules, so that, while we grow in wisdom, we approach the strong man's home. They tell us that we are moving at such a rate that the distance from star to star is but just a good geological day's journey; and hereby they confirm the story which is written upon the crust of our globe and prove that the earth and the skies have been measured out with the same unit of measure.—*Professor Benjamin Peirce, of Harvard University, the foremost American mathematician of his day, from his retiring address as president of the American Association for the Advancement of Science, delivered at Cleveland, Ohio, in July, 1853.*

BOOKS ON SCIENCE FOR LAYMEN

THE INTELLIGENCE OF CRIMINALS[1]

THE author of this volume presents the results of his psychological study of 10,413 prisoners, representing *all* the admissions to three penal institutions in Illinois during the period 1920–1927. The data for the three are separately given, so that the penitentiary and reformatory types of prisoners are not confused. In order that data comparable with the Army draft studies might be secured, the same general procedures and batteries were employed as were used in the Army testing.

Among the chapters we find the following titles, which serve to indicate the scope of the work: Intelligence in Relation to Nativity and Race, Type of Crime and Recidivism; Intelligence in Relation to Age, Height and Weight; Intelligence in Relation to Socio-Economic Characteristics; Type of Crime in Relation to Nativity and Race, Intelligence and Recidivism.

In very brief summary, it may be said that Tulchin finds no startling discrepancy between the test score classification of the inmates and that of the Army draft group; in other words, there seem to be no close association between crime and "intelligence." There is found, however, a relationship between the rating and the general type of offense. "For nearly all nativity and race groups, the highest median Alpha scores are made by the men committed for fraud, and the lowest scores by men committed for sex crimes." Tulchin points out the need of considering the nativity and race distributions of institutions in making comparisons: considerable variations of rating are found in relation to these factors.

The volume represents one of the many valuable contributions to the literature of forensic psychiatry inspired and initiated by the late Dr. Herman M. Adler, to whose memory the book is dedicated. It is comprehensive, thorough, sound, clear and informative. It should, and undoubtedly will, be read by every one interested in psychometrics, criminology and mental deficiency, as one of the most significant studies of its kind. The fact that the book is planographed detracts very little from its readibility.

WINFRED OVERHOLSER, M.D.
SAINT ELIZABETHS HOSPITAL,
WASHINGTON, D. C.

[1] *Intelligence and Crime.* By Simon H. Tulchin. xiii + 166 pp. $2.00. 1939. University of Chicago.

RECENT BOOKS ON BIRDS

"CANADIAN Water Birds. Game Birds. Birds of Prey. A Pocket Field Guide"[1] is a welcome addition to the ever-increasing list of fully illustrated, popular, but scientifically accurate and authoritative manuals for bird identification. Unlike most other books in its general class, the present one is intended primarily for the sportsman and its contents are limited to water birds, game birds and birds of prey, leaving out altogether the small song birds, the woodpeckers, the cuckoos and other related groups. (These birds are covered in a companion volume.) The keys for identification are made as simply as possible, and the lavish use of illustrations (nearly 100 plates in color and over 150 text drawings in black and white depicting nearly 200 different species) is obviously directed at helping the novice to make his identifications with the least waste of time and with the greatest probability of accuracy of result. The book is highly recommended by the reviewer.

"WILD Bird Neighbors"[2] is of a very different type, being a series of first-hand

[1] P. A. Taverner. 291 pp. $2.50. 1940. David McKay Company.

[2] Alvin M. Peterson. 283 pp. $2.00. 1940. The Bruce Publishing Company.

field studies of about thirty-five common species of birds, to each of which is devoted a small chapter. While the bulk of the material is not such as to constitute additions to existing knowledge, the fact that the notes and photographs (many of which are excellent) are all original makes the book worth reading. It is written in an interesting, easy style, which should make it a good book for beginners and people to whom the study of birds in the field is a mild and pleasant avocation.

The last of the books herein reviewed deals with a single species. "The Autobiography of an Egret"[3] is a book of superb photographs (39 illustrations) of one of our most attractive and beautiful birds. The fact that the author did a good deal to save this species from local extermination at a time when it was seriously depleted by the plume hunters for the millinery trade explains a rather too obvious sentimentality in parts of the text. The book is written in the first person as though an egret were telling the story, a type of writing that may have its advocates, but which leaves the reviewer inclined to be unsympathetic and hypercritical. There is much valuable material in the book, if one knows how to extract it from the narrative in which it lies imbedded.

HERBERT FRIEDMANN

LET US REASON TOGETHER[1]

IF John Dewey ever wrote anything that was not worthy of careful reading by thinking persons, it has escaped my attention. This latest book of his not only exhibits his penetrating insight and precision of statement, but it is almost tragically timely. It discusses the question of individual freedom at a time when it has disappeared from a large part of the world and is giving rise to hysteria in the remainder.

Dewey opens with a discussion of "The Problem of Freedom" in which he inquires concerning the reasons men have had for desiring individual liberty. "Is love of liberty ever anything more than a desire to be liberated from some special restriction? And when it is got rid of does the desire for liberty die down until something else feels intolerable?" There is no simple, categorical answer to such questions, and Dewey does not give one. As he shows, human motives are enormously involved, and many of the tragic mistakes of mankind have been due to over-simplification of things that are fundamentally complex. His third chapter on "The American Background" will be especially illuminating to American readers because it raises questions concerning the origin and the meaning of the lofty sentiments found in the Declaration of Independence and the Constitution of the United States. This discussion will be illuminating because the intelligent American reader will have a background of historical information and attitudes that will make its statements easily comprehensible. But few will have the broad knowledge of history, psychology and philosophy necessary to grasp readily the full content of his pages on "Totalitarian Economics and Democracy" and "Democracy and Human Nature." This fact is not a good reason for not reading this book with care. On the contrary, the reader should be grateful that so much knowledge and wisdom are available in such a small compass.

In the final chapter on "Democracy and America" Dewey does not make "the eagle scream" or point to any easy and certain road to Utopia. "We have no right to appeal to time to justify complacency about the ultimate result. We have every right to point to the long non-

[3] Edward A. McIlhenney. 58 pp. $2.00. 1939. Hastings House.

[1] *Freedom and Culture.* By John Dewey. 176 pp. $2.00. 1939. G. P. Putnam's Sons.

democratic and anti-democratic course of human history and to the recentness of democracy in order to enforce the immensity of the task confronting us. . . . We have every right to appeal to the long and slow process of time to protect ourselves from the pessimism that comes from taking a short-span temporal view of events—under one condition. We must know that the dependence of ends upon means is such that the only ultimate result is the result that is attained today, tomorrow, the next day, and day after day, in the succession of years and generations. Only thus can we be sure that we face our problems in detail one by one as they arise, with all the resources provided by collective intelligence operating in cooperative action. At the end as at the beginning the democratic method is as fundamentally simple and as immensely difficult as is the energetic, unflagging, unceasing creation of an ever-present new road upon which we can walk together.''

F. R. MOULTON

BIOLOGY MADE SIMPLE: TOO SIMPLE[1]

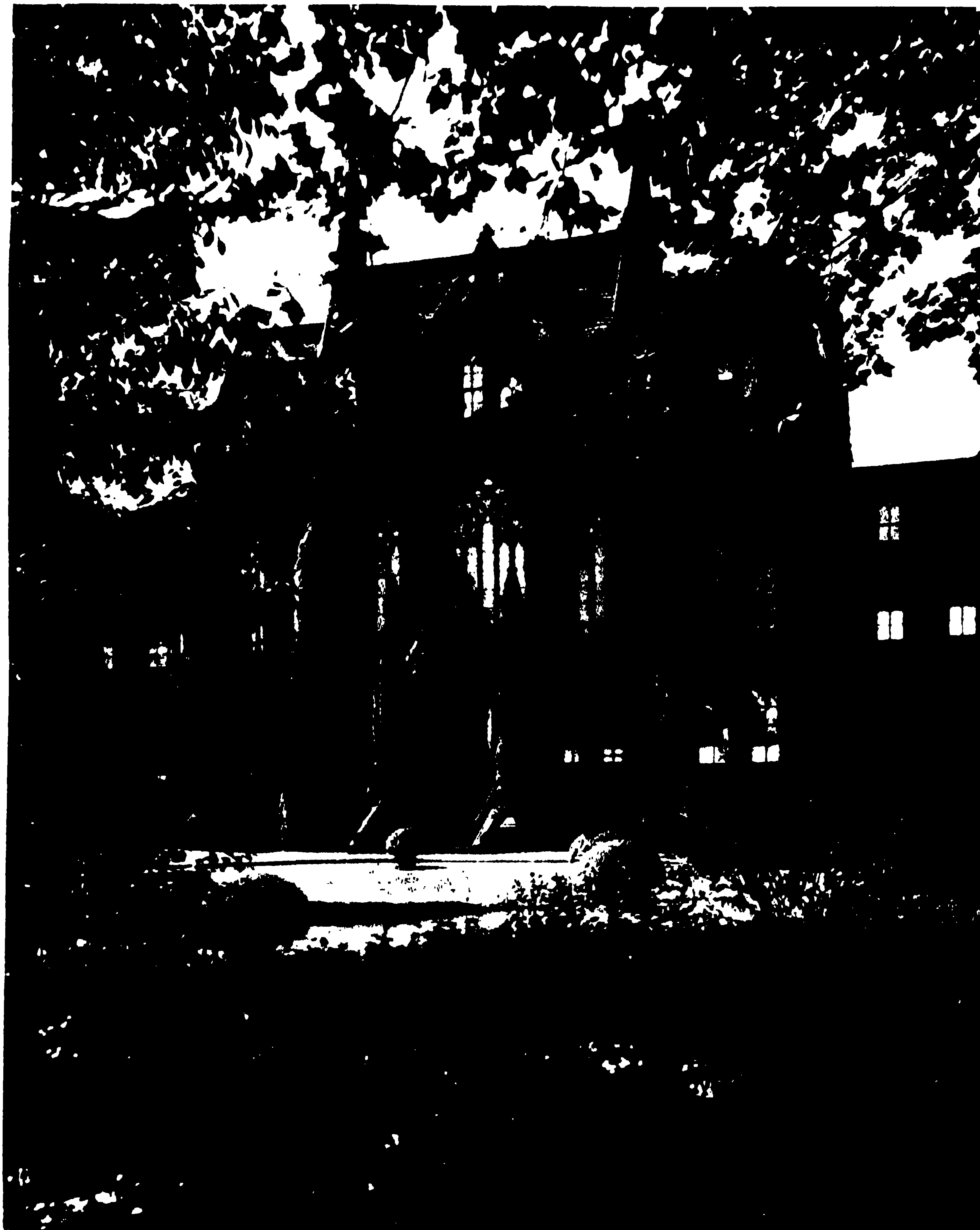
THE human body is wondrously constructed and its multitude of intricate and nicely balanced activities are fascinating subjects to all. The average ''man on the street'' is woefully ignorant of his own person: what he is, how he is made and how he ''works.'' As a result, more of us abuse our machines than use them. To describe and discuss the significance of human biology in such manner that the fundamentals are clarified to the uneducated lay reader is a splendid objective. This little book, sponsored by the American Association for Adult Education, ambitiously attempts, but does not succeed, to explain the evolution of mankind, human anatomy, the physiology of muscles, digestion, metabolism, circulation, immunity, respiration, reflex action, thought and reproduction, all in 125 small pages.

The accomplishment falls so far short of the objective that one could hardly recognize the latter but for an explanatory note. Though there are few, if any, absolute mis-statements of fact in the book, much of the material is so vague and idealistic that a grossly false sense of inane simplicity prevails. As reading matter for the fifth grade it could do much good. The whole style is that of a story-book for children. The reiteration of the personal pronoun becomes a burden and a bore. If the Committee for Adult Education deems such phraseology as ''On St. Valentine's Day true lovers send each other a picture of a pump. That is what your heart is . . . '' appropriate for adult education, it is a sad commentary upon their opinion of adult intelligence in America. Much more harm can be done by ''talking down'' with baby talk to those innumerable adults hungry for factual knowledge than by an occasional technical expression which may require amplification. These people want to look up, to be stimulated and bitterly resent such pap as this. Lack of education does not imply stupidity nor even lack of curiosity. If this over-simplification is intended to intrigue the curiosity of the dull ignoramus it will likewise fail, for he is sincerely convinced that he already ''knows it all.''

Similarly, the illustrations are detrimental to clarity. Attempting to be simultaneously diagrammatic and sensationally dramatic they merely confuse and mislead. This book can not be recommended except for small grammar-school children, and for them there are far better biology texts. It is too simple.

EDWARD J. STIEGLITZ

[1] *Picture of Health.* By James Clarke. Illustrated. 125 pp. $0.60. 1940. Macmillan Company.



COLLEGE HALL OF THE UNIVERSITY OF PENNSYLVANIA

THE PROGRESS OF SCIENCE

THE BICENTENNIAL CELEBRATION OF THE UNIVERSITY OF PENNSYLVANIA

A BICENTENNIAL Conference will be held by the University of Pennsylvania, beginning September 16 and ending September 20, as part of the program marking the observance of the two hundredth anniversary of the university's origin. The program will consist of lectures and papers by a group of about two hundred distinguished European and American scholars and leaders in the various fields of science and thought. The offerings will represent the broad interests and significant contributions to learning. In the field of the humanities the symposia are planned to bring out the continuity of culture. In other fields they will trace the trends of modern thought and the advances of science. The symposia and meetings constituting the program of the Bicentennial Conference are divided into six general fields—the medical sciences, the natural sciences, the social sciences, the humanities, the fine arts and religion.

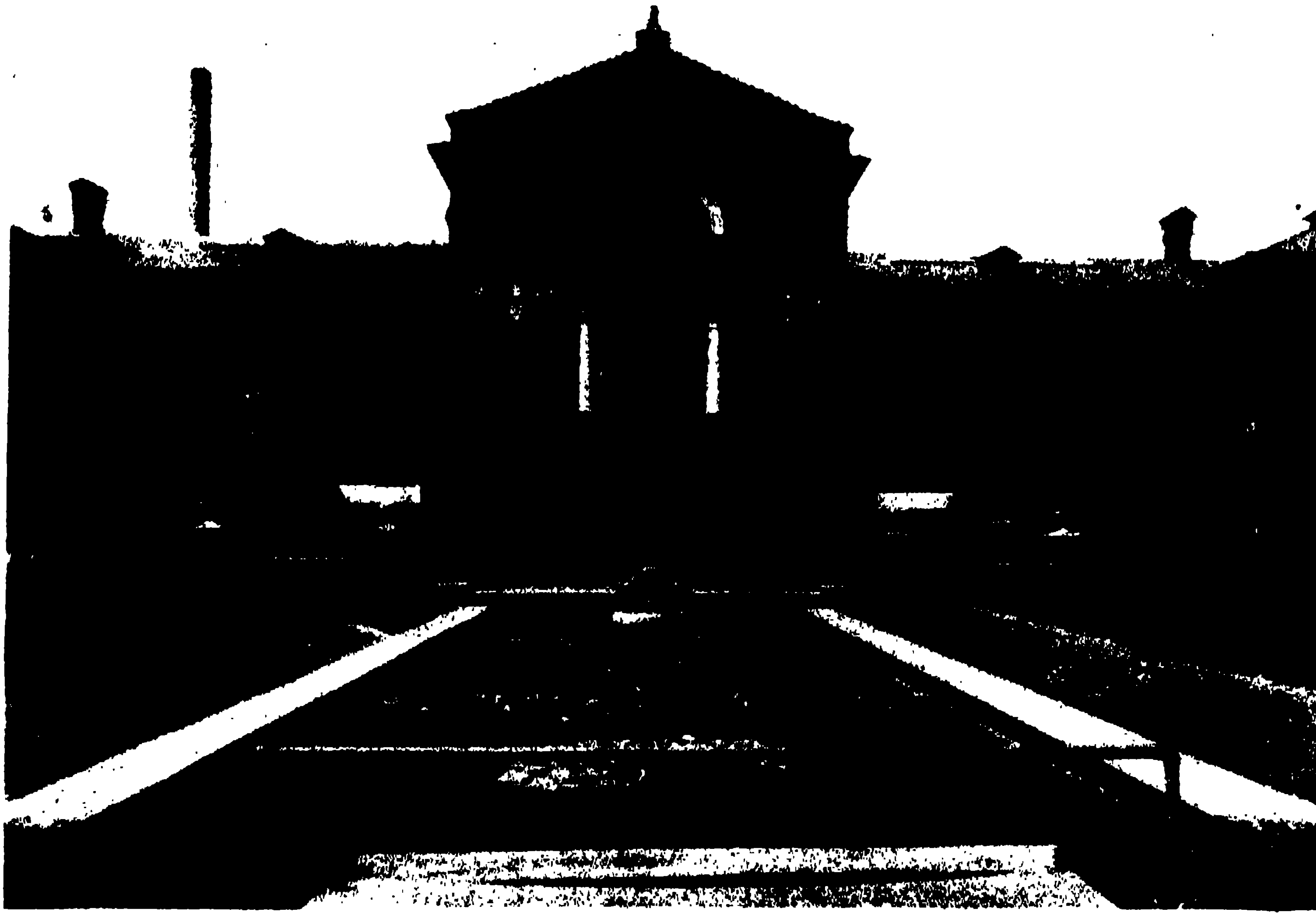
The fullest section of the program, with fifty-eight papers, is that on the medical sciences. A heavy advance registration reflects wide-spread interest in sulfanilamide and its derivatives, one of the most effective medicines discovered during this century. Dr. Eli K. Marshall, Jr., of the Johns Hopkins University, and Dr. John S. Lockwood, of the University of Pennsylvania, will review the efficacy of these drugs and the mechanism of their action. The search for germ-killing chemicals, involving the study of bacterial enzymes will be described by Dr. René Jules Dubos, of the Rockefeller Institute for Medical Research.

The symposium on nutrition will be addressed by Dr. Elmer V. McCollum, of the Johns Hopkins University, codiscoverer of vitamin A and a leading investigator also in vitamin D and mineral metabolism; Dr. Conrad A. Elvehjem, of the University of Wisconsin, outstanding worker in the continually broadening field of the vitamin B complex; and Dr. Cyril N. H. Long, of Yale University, known for his work in endocrine gland research.

Dr. Lawrence J. Henderson, of Harvard University, noted for his studies on the physico-chemical relationships in the blood, will deliver one of the principal addresses. He will concern himself with the social as well as the medical aspects of man under the broad topic, "The Study of Man." Dr. William Mansfield Clark, of the Johns Hopkins University, will be another of the principal speakers in this section, and Dr. Evarts A. Graham, professor of surgery at Washington University, will speak on "Two Centuries of Surgery."

The medical symposia will cover a wide variety of subjects besides those already mentioned. They include sessions on the female sex hormones, diseases peculiar to old age, virus diseases, problems of high blood pressures, new leads on the search for the cause of cancer, and the relation of animal diseases to human welfare.

The round table on the history of science, ranging from "The Mesopotamian Background for the Beginnings of Science" to "The Rise of Modern Scientific Medicine," is attracting much interest in the field of the natural sciences, which is the second largest of the six main divisions of the program. To mention a few of the outstanding names on the program, there are: Dr. Otto Eduart Neugebauer, formerly of Germany, now of Brown University, and one of the leading authorities on the history of mathematics and astronomy; Dr. Henry E. Sigerist, director of the Institute of the History of Medicine of the Johns



THE UNIVERSITY MUSEUM

Hopkins University; and Dr. George Sarton, editor of *Isis* and *Osiris*, and lecturer on the history of science at Harvard University. Dr. Sarton will act as chairman of the round table.

Secretary Henry A. Wallace, of the United States Department of Agriculture and the Democratic nominee for vice-president, has recently accepted an invitation to address the symposium on the conservation of renewable natural resources, a matter of increasingly serious concern. Another participant will be Dr. Paul Bigelow Sears, of Oberlin College. Determination of the American climate and weather of several thousand years ago by means of well-preserved "fossil" grain pollens, and the accurate dating of droughts, wet spells and ancient human habitations by means of tree rings are among the topics to be discussed by Dr. Sears, and by Dr. Andrew E. Douglass, of the University of Arizona.

A particularly large advance registration has been made for the psychology symposium which deals with the contribution of this study to education and business.

The meeting on nuclear physics, to be addressed by the Nobel Prize winner, Dr. Enrico Fermi, formerly of Rome and now of Columbia University, also is attracting considerable advance interest as are the sessions on genetics, evolution and heredity, and several others. Dr. Frank B. Jewett, president of the Bell Telephone Laboratories and of the National Academy of Sciences, will make one of the principal addresses.

Herbert Clark Hoover, who will speak Wednesday evening, heads an impressive list of speakers in the social science field. Other notables include Hu Shih, Chinese Ambassador to the United States, Dr. Wesley Clair Mitchell, professor of economics at Columbia University and noted for his work on index numbers and business cycles. The war refugee problem will be considered in a

group of papers on "Forced Mass Migrations."

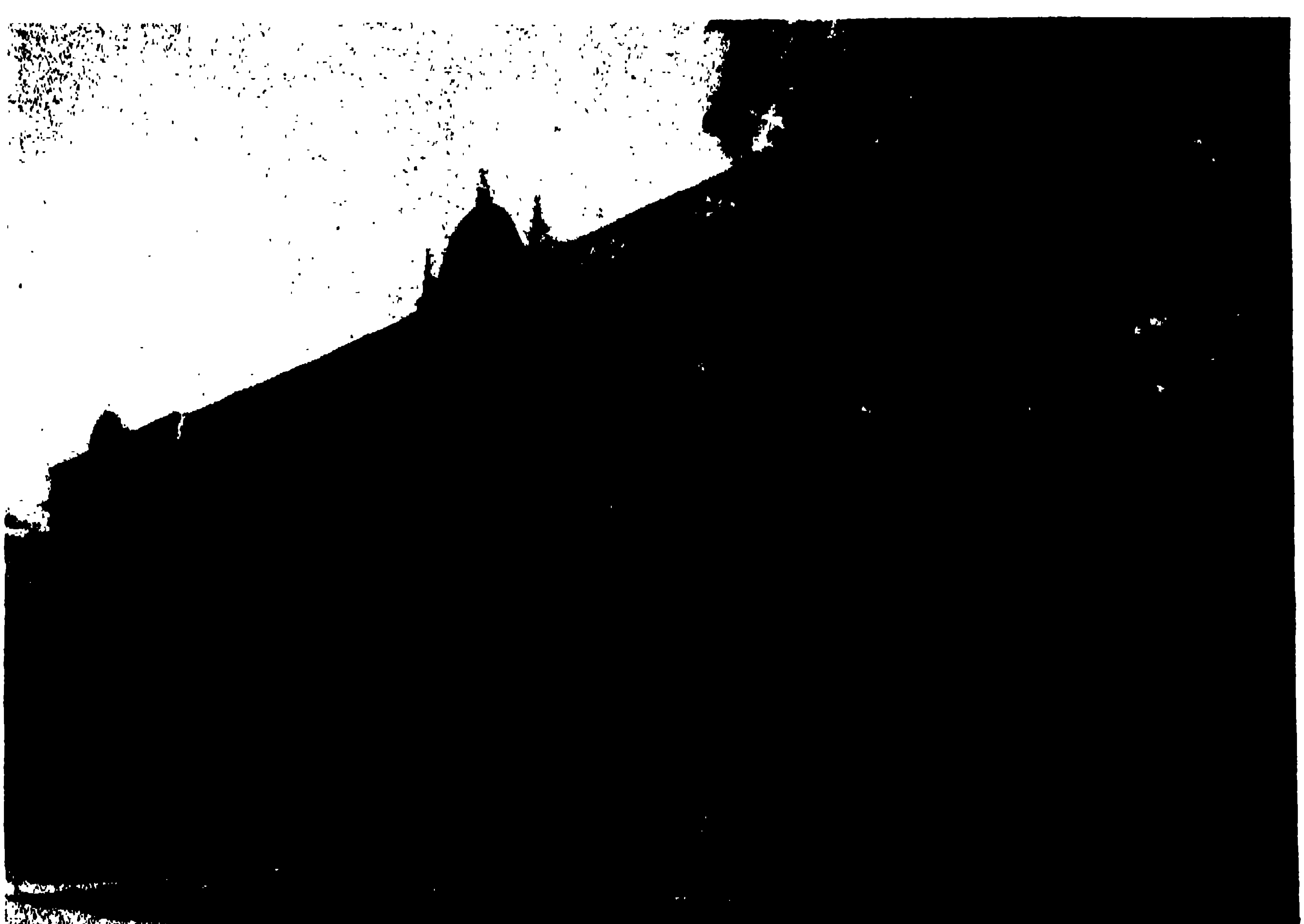
Industrial relations will be discussed by six members of a panel, including William M. Leiserson, of the National Labor Relations Board; James M. Landis, dean of the Harvard Law School, and Joseph Willits, director for the Social Sciences for the Rockefeller Foundation. Dr. Willits will act as chairman.

The social implications of modern architecture will be among the topics taken up in the fine arts section by such speakers as Joseph Hudnut, dean of the faculty of the Harvard University Architectural School, and Frank Lloyd Wright, pioneer in the development of modern architecture.

Two distinguished Frenchmen will address the conference in the fields of religion and humanities: Dr. Maritain, author and philosopher of the Catholic Institute of Paris and the Institute of Medieval Studies of Toronto, will speak on "Trends in Religious Thought"; Professor Gilson, who is professor of medieval philosophy at the College of France, and director of the Institute of Medieval Studies at the University of Toronto, will give a lecture on "The Middle Ages and the Unity of Western Civilization."

In addition to the Bicentennial Conference, the program for the University of Pennsylvania's Bicentennial Week Celebration from September 16 to 21 will include cultural and scientific exhibits, laboratory and clinical demonstrations, convocations for the conferring of honorary degrees, meetings for alumni and alumnae, and a number of other events.

On the afternoon of September 20, the Philadelphia Convention Hall, near the campus, will be the scene of impressive exercises which will include a Convocation of the University Council for the conferring of honorary degrees upon President Franklin D. Roosevelt and Sir



THE ZOOLOGY BUILDING

Lyman Poore Duff, Chief Justice of the Supreme Court of Canada. Both President Roosevelt and Sir Lyman will deliver addresses during the convocation, at which President Thomas S. Gates of the university will preside; there also will be an address by Justice Owen J. Roberts, of the Supreme Court of the United States.

At the closing convocation on September 21, approximately five hundred delegates representing universities, colleges, and learned societies at the Bicentennial Celebration will be presented formally, and the university will confer honorary degrees upon a score of men distinguished in various fields. In addition, the program will include addresses by Governor Arthur H. James, of Pennsylvania; President Gates, and Dr. George Wm. McClelland, provost of the University of Pennsylvania. H. L. H.

NATIONAL DEFENSE RESEARCH COMMITTEE

THE National Defense Research Committee was set up under an order of the Council of National Defense dated June 27, 1940. The order recites that the committee "shall correlate and support scientific research on the mechanisms and devices of warfare, except those relating to problems of flight included in the field of activities of the National Advisory Committee for Aeronautics. It shall aid and supplement the experimental and research activities of the War and Navy Departments; and may conduct research for the creation and improvement of instrumentalities, methods and materials of warfare." In

FIRST MEETING OF THE NATIONAL DEFENSE RESEARCH COMMITTEE
Seated, left to right: BRIGADIER GENERAL G. V. STRONG, DR. JAMES B. CONANT, DR. VANNEVAR BUSH, *chairman*, DR. RICHARD C. TOLMAN, *vice-chairman*, DR. FRANK B. JEWETT AND (*standing*) DR. KARL T. COMPTON, DR. IRVIN STEWART, *secretary*, AND REAR ADMIRAL HAROLD G. BOWEN.

carrying out its functions the committee is empowered to enter into contract with organizations and individuals. The members of the committee are:

Vannevar Bush, *chairman*
President, Carnegie Institution of Washington
Richard C. Tolman, *vice-chairman*
Dean of the Graduate School,
California Institute of Technology
Rear Admiral H. G. Bowen
Designated by the Secretary of the Navy
Conway P. Coe
Commissioner of Patents
Karl T. Compton
President, Massachusetts Institute of Technology
James B. Conant
President, Harvard University
Frank B. Jewett
President, National Academy of Sciences
Brigadier General G. V. Strong
Designated by the Secretary of War

The committee will act in close cooperation with the War and Navy Departments. So far as possible the committee expects to utilize existing facilities, and it will act directly only where there is reason for such direct action. The committee is accumulating information as to special research facilities of academic and industrial organizations which might be brought to bear upon particular defense research problems. The response which has already been received from scientists both in academic institutions and in industry shows clearly that the committee will have the cordial cooperation of this entire scientific group in its efforts.

The relations between the committee on the one hand and the National Academy of Sciences and the National Research Council on the other, will be quite close. Work already under way by the Academy and Council will continue; and the committee will cooperate with the academy and the council as they proceed on additional problems which they undertake in their capacity as the organizations primarily charged with the duty of advising agencies of government on their scientific problems.

There will also be a close working relationship between the committee and the newly created Inventors' Council. The council, in close contact with the Army and Navy, will make a preliminary appraisal of the usefulness of new ideas and inventions, and there will be referred to the committee those upon which further scientific research is needed to complete development and insure utility.

Because of the nature of the problems with which it will deal, the committee will not reveal the particular problems upon which it may be engaged at any time. Its primary purpose will be to bring to bear upon the problem of the creation and improvement of the devices and mechanisms of warfare the efforts of competent civilian scientists and engineers to supplement the work already being carried on directly by the armed services.

VANNEVAR BUSH,
Chairman

AWARD OF THE NOBEL PRIZES IN CHEMISTRY

THE will of Alfred Bernhard Nobel, who died in 1896, provided that the bulk of his vast munitions and oil fortune should be placed in trust for the establishment of five annual prizes to be awarded for contributions to physics, physiology and medicine, chemistry, literature and peace. The will stated, "I declare it to be my express desire that, in the awarding of prizes, no consideration whatever be paid to the nationality of the candidates."

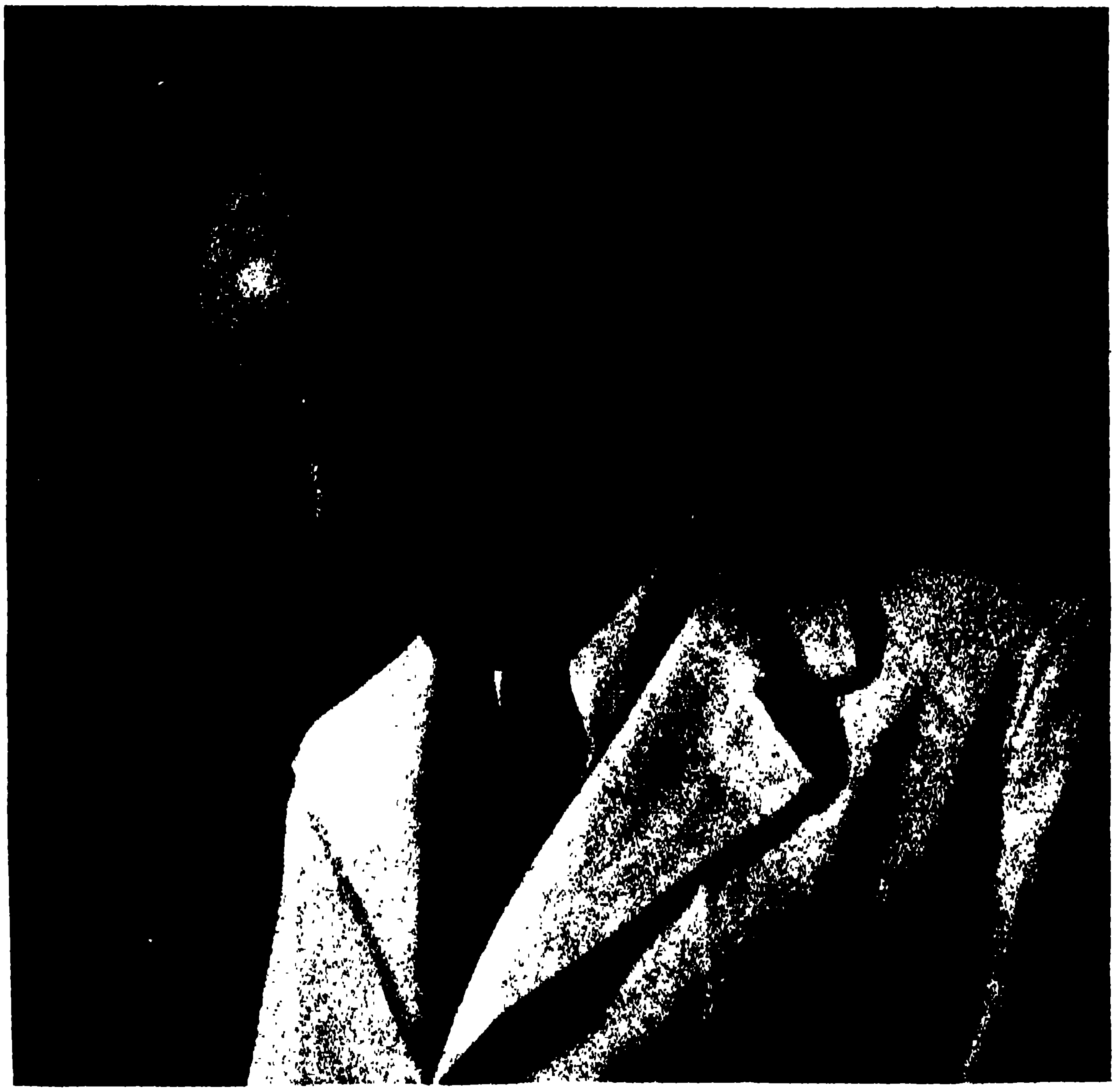
The Royal Swedish Academy of Sciences in Stockholm several months ago announced the Nobel Laureates in Chemistry for 1938 and 1939. Chosen for the delayed 1938 award was Professor Richard Kühn of Heidelberg and jointly for the 1939 award were Professor Adolf Friedrich Johannes Butenandt of Berlin

PROFESSOR RICHARD KÜHN

and Professor Leopold Ružička of Zurich. Professors Kühn and Butenandt are honored no less because the German government will no longer permit its subjects to accept Nobel Prizes. It took this stand in 1935 because Carl von Ossietzky—then in a concentration camp—was designated as the recipient of the Nobel Peace Prize.

Professor Richard Kühn was born in Vienna on December 3, 1900. He achieved his early training under Willstätter and became a *privat-dozent* at the University of Munich in 1925. The next year he went to Zurich as professor and at the age of 30 became head of the department of chemistry of the Kaiser Wilhelm Institute for Medical Research when it opened in Heidelberg in 1930. In 1937 he was made director of the institute.

Professor Kühn's investigations embrace important contributions to many problems in organic and physiological chemistry. His early work was in the field of pure organic chemistry, where he was able to synthesize and study the behavior of long chains of unsaturated hydrocarbons. This led naturally to the study of the carotenes, and in this



PROFESSOR LEOPOLD RUŽIČKA

field Kühn made important contributions to the knowledge of the structure of vitamin A.

Simultaneously with Karrer, Kühn described the constitution of riboflavin, vitamin B_2, and further showed its relationship to the yellow enzyme of Warburg, which is involved in the oxidation of sugar in the body cells. His most recent publications are concerned with the chemistry and biological properties of certain substances found in lower organisms.

Although carried out in separate laboratories, the investigations of Professors Ružička and Butenandt in the field of the male sex hormones are peculiarly complementary, and the joint award of the 1939 Nobel Prize in chemistry was appropriate.

Professor Leopold Ružička, who was born on September 13, 1887, at Vukovar, Yugoslavia, received his degree in engineering and became *privat-dozent* at Zurich in 1918, where he has remained with the exception of three years spent as professor at the University of Utrecht. He is now professor of chemistry at the University of Zurich.

Ružička first became widely known for his synthesis of musk, greatly in demand as an ingredient of perfumes. This synthesis, besides showing the existence of a new class of chemical compounds, saved from possible extinction the now rare musk oxen of Tibet.

Dr. Adolf Butenandt was born on March 24, 1903, in Wesermunde, Germany. He studied at the University of Marburg and achieved his doctorate at the University of Göttingen, where he remained as *privat-dozent* under Professor A. Windaus until 1933. He was then for three years professor at the

PROFESSOR ADOLF FRIEDRICH JOHANNES BUTENANDT

University of Danzig and in 1937 he became director of the Kaiser Wilhelm Institute of Biochemistry in Berlin. The training under Windaus, himself a Nobel Prize winner for his studies on the vitamin D and bile acid steroids, provided a thorough basis for Butenandt's comprehensive investigations on the sex hormone steroids.

Following the discovery by Zondek and Aschheim a little over a decade ago that the urine of pregnant women was rich in female sex hormones, Butenandt made important contributions to the knowledge of the structure of these compounds. In addition he worked out the formula of an inactive steroid, pregnanediol, found in pregnancy urine by Marrian. Several years later this substance was shown to be an excretion product of progesterone, a pregnancy-maintaining principle of the ovary, whose formula had similarly been determined by Butenandt. Of this demonstration, Willard M. Allen, of the University of Rochester, wrote in 1939, "The fact that the structure of pregnanediol was already known was of course of the greatest importance, and the beautiful work of Butenandt establishing its structure years before it appeared to have any relation to the sex hormones is a classical example of the value of science for its own sake."

Although the investigations of Ružička contributed substantially to the knowledge of the structure of the female sex hormones, the landmarks of his work are more pronounced in the field of the male sex hormones, which developed somewhat later.

When attention turned to the steroids found in male urine, Butenandt succeeded in isolating in 1934 the first male hormone in crystalline form, androsterone. Ružička described in 1934 and 1935 the experiments definitely establishing its chemical structure. He was able to start with a common steroid found throughout the body, cholesterol, and by

appropriate chemical treatment transform it into the potent male hormone, androsterone.

Another male hormone, considerably more potent than androsterone, was found by Gallagher and Koch in extracts of bull testis. By the time Laquer had isolated this hormone in crystalline form, both Ružička and Butenandt had succeeded in preparing it synthetically from cholesterol, and the structure of testosterone, the most potent male hormone known, was proven.

Butenandt demonstrated the structure of another hormone in male urine, dehydroandrosterone, and showed its relationship to androsterone. Later he was able to start with a vegetable steroid, stigmasterol, and from it synthetically produce both male and female sex hormones.

Due to the complexity of the molecules of the sex hormones, many closely related derivatives of these substances are theoretically possible. It has been amply demonstrated for many chemical compounds that a slight change in the molecule will induce tremendous changes in its activity. In the cause of pure science as well as in the pursuit of more active hormones, Butenandt and Ružička explored in a systematic manner the field of compounds related to the male sex hormones. Their achievements in this pursuit comprise a long list of substances derived from male hormones which they have synthesized and biologically assayed, finding some less active than testosterone in male properties, some without activity and some with female properties.

The isolation of androsterone by Butenandt and its synthesis by Ružička made possible the first international standard for male hormones, established in 1935 on the basis of androsterone.

C. P. Kraatz
Chicago Medical School

AN AURORA IN A TEST-TUBE

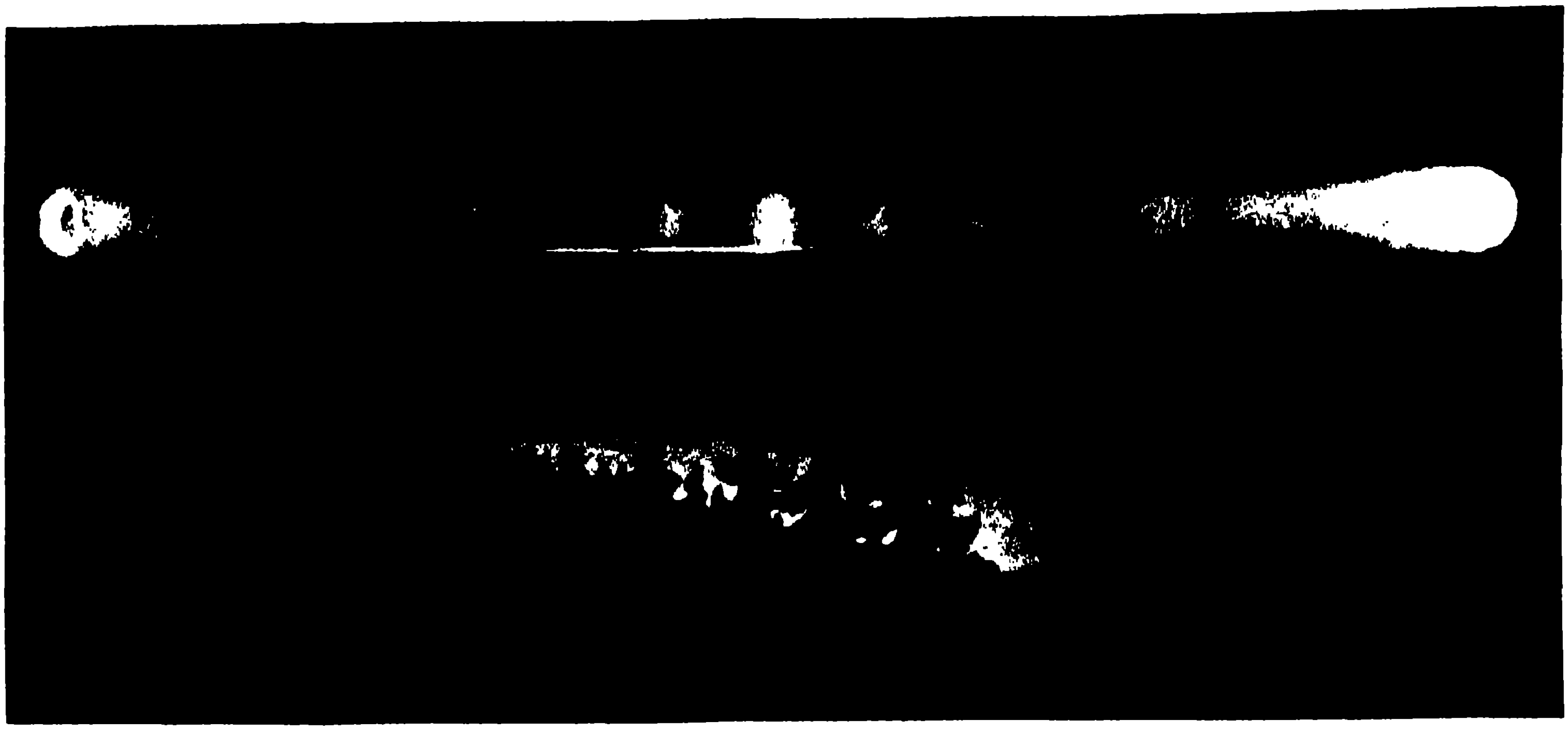
Perhaps no effect produced in the planetarium is more popular than the aurora. For several years we have had one in the north and another in the south, and it was a revelation to the audiences to know that there were southern as well as northern lights. While these projection devices produce light patterns on the sky that resemble some types of auroral displays, they do not show the cause of this ghostly light.

To supply this need we have built a glow tube demonstrator that is shown and simply explained in the preliminary talk that precedes each planetarium demonstration. In order to make the connection with northern lights clear we built the tube into a sky background and concealed the apparatus.

The glass tube is about 4 feet long and 3 inches in diameter, made of Pyrex glass. In each end is an electrode made of aluminum. A 15,000 volt transformer is connected across the terminals. The one we use is the ordinary neon sign type. The leads are brought up through fiber tubes for protection and to conceal them from view.

At the center of the tube, and on the side turned away from the audience, is a stop-cock for controlling the pressure on the tube. A Hivac pump is connected at one end of the tube.

In operation, the stop-cock is closed, the pump started and the transformer circuit closed. While the air pressure inside the tube drops, brush discharges appear on the electrodes. Within about two minutes after starting a flash or two across illuminates the tube and finally a salmon red glow. At first the glow is very unsteady, breaking down into a series of short bright and dark spots, locally known as "frankfurters." This

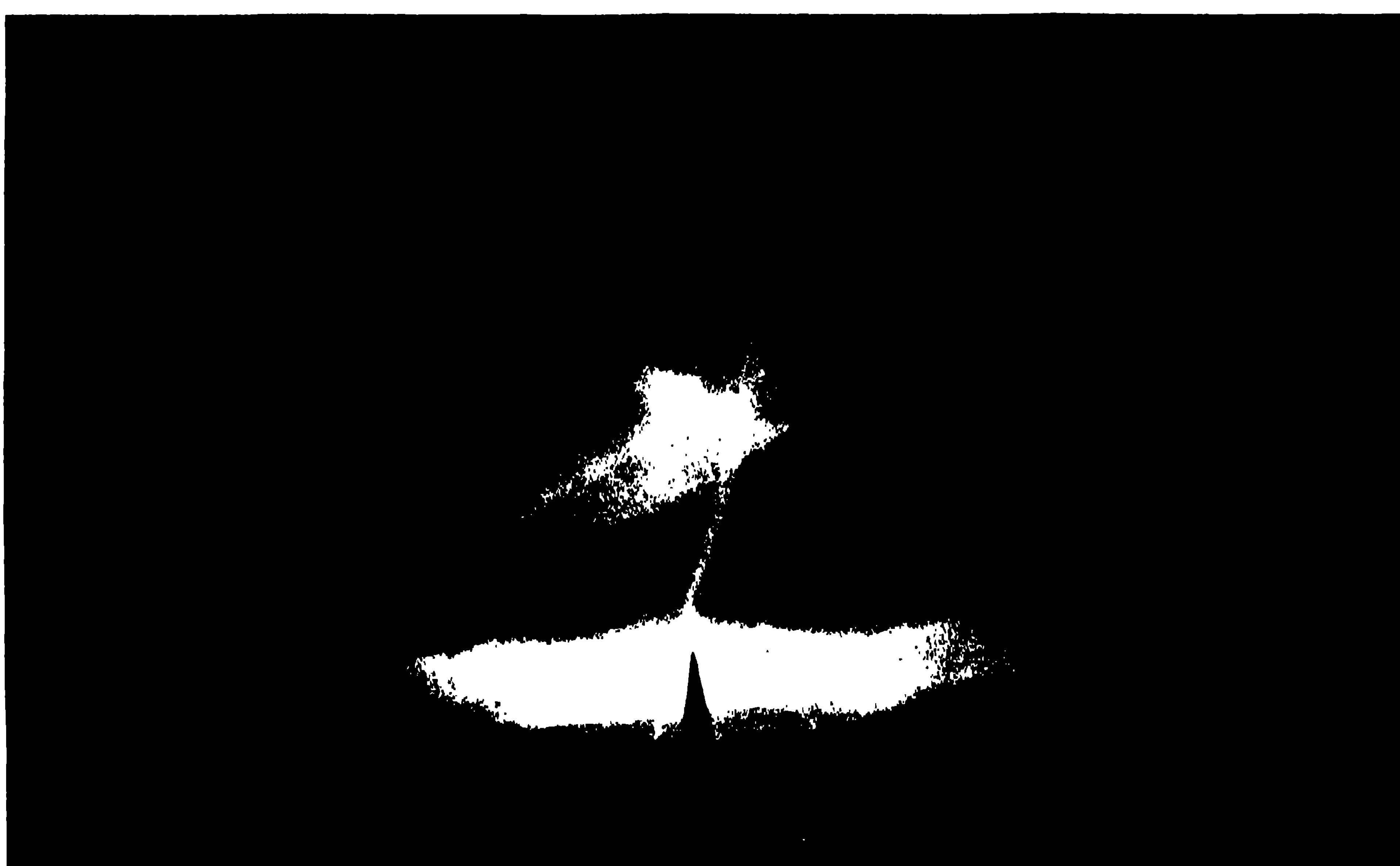


THE "AURORA-PRODUCING" GEISSLER TUBE

is not a bad name as that is exactly what they look like. This unstable condition finally gives way to a steady state of glow.

After further reduction of pressure bright spots appear about two inches apart along the tube. By means of an alnico magnet these rings or disks are moved along in various ways. At the end of about six minutes, the stop-cock is opened and the tube brought back to atmospheric pressure.

No attempt is made to go into the physics of either this Geissler tube or the



THE "NORTHERN LIGHTS" PROJECTED ON PLANETARIUM SKY

BRIGHT-COLORED STREAMERS ARE SEEN AGAINST THE NORTHERN SKY, WITH THE LUMINOUS CLOUDS ABOVE THE HORIZON.

aurora. The simple explanation includes the source of this auroral glow in the sun-spots and the similarity to the electrical energy from the transformer. The exhausting of the tube is compared to going high up into the stratosphere where the aurora appears. The magnetic influence of the earth attracting the glow and causing it to move so mysteriously is illustrated with the magnet's effect on the tube's light.

The experiment has proved most interesting and is one of a series that we perform each month to illustrate some part of the month's topic. A somewhat similar use was made of the glow tube at the Fels Planetarium several months ago. In Dayton C. Miller's book, "Sparks, Lightning, Cosmic Rays," based on his 1937 Christmas Week lectures at the Franklin Institute, an illustration of this hook-up is shown and references given for even more complete study than he gives this type of apparatus.

The rich coloring, violet and salmon red, the notion of "an aurora in a test-tube," proves to be an exciting experience to the audience.

WILLIAM H. BARTON, JR.

TAFFY HAS MERITS

OLD-FASHIONED molasses is placed at the head of the list of iron-containing foods that are useful in the treatment of nutritional anemia, by the studies recently completed at the Massachusetts Institute of Technology.

They show that the old childhood delicacy of molasses on bread may have been a good medicine for growing children, among whom, as they found, nutritional anemia is prevalent. With experiments in the test-tube and on rats, Dr. Robert S. Harris, Dr. John W. M. Sunker and L. Malcolm Mosher have found that molasses is a rich, easily available and relatively inexpensive source of food iron. In effectiveness, it compares favorably with chemicals customarily injected into the blood of anemic people.

That the poorer and less refined grades of molasses are richer in iron that can be used by the body to build hemoglobin (the red coloring matter in the blood corpuscles) than the higher grades is also revealed by the experiments. Since molasses is a by-product of the manufacture of sugar from sugar cane, the removal of greater amounts of sugar from the cane leaves more concentrated residues of the other constituents, among them iron.

A table has been prepared by the institute's biochemists to show the position of molasses with respect to usable iron in comparison with other common foods that contain iron. Molasses stands at the top of the list, with about 6.1 parts of usable iron per 100,000 parts by weight of molasses. Beef liver stands second, with 5.6 parts per 100,000, and oatmeal third, with 4.6. Apricots, eggs and raisins, foods listed by some doctors as especially valuable in curing anemia, were found to contain only about two thirds, a half, and a third, respectively, as much usable iron as does molasses. Spinach is far down on the list, with only 0.5 part per 100,000.

The Institute scientists began by observing that recent medical studies on anemia have shown that the deficiency disorder is more prevalent than had been suspected. More than 40 per cent. of infants are anemic, and the blood of as high as 70 per cent. of adult women was found to be deficient in iron. Few individuals were found with absolutely normal blood.

They also observed that molasses was known to be rich in iron, but that little was known about how much of that iron the body can use. They proceeded to

investigate by means of two different methods—one biological and the other chemical.

In the biological tests, a group of rats was fed on diet low in iron for about a month to produce a nutritional anemia. Then measured amounts of three grades of molasses were added to their diets. Subsequent tests of the blood from the rats showed that the molasses caused definite increases in the amounts of hemoglobin, the less refined the molasses the better the results.

In the chemical tests, the amounts of "ionizable" or soluble iron in molasses were measured directly by chemical methods. Of course, the value of a food as a source of iron is not measured by its total iron content, but by the amounts of its "usable" iron. J. J. R.

A MILLION VACCINATIONS FOR YELLOW FEVER

Just as the workers of the Rockefeller Foundation were concluding, a few years ago, that the organism (virus) which produces yellow fever had become as extinct as the Dodo, this serious disease reappeared in various areas in South America. It struck in many places from 500 miles north of the equator to 2,000 miles south of it, from the eastern slopes of the Andes to the mouth of the Amazon, from sea level to an altitude of 5,000 feet. Approximately 40,000,000 persons were exposed to the attacks of an invisible and deadly enemy against which they had no means of protection.

All earlier yellow fever was transmitted to human beings by the *Aëdes aegypti* mosquito, the life cycle of the causative virus being mosquito-man-mosquito. Consequently the disease could be stamped out by destroying all infected human beings or all infected mosquitoes—the latter were chosen for the sacrifice. The new yellow fever virus has not been found to be transmitted to man by any mosquito; in some unknown way it steals out of the jungle and slays its victims. In spite of its different method of transmission, it is indistinguishable from the earlier form both in its effects upon human beings and in their acquiring immunity to it. The two strains of virus producing the disease differ sensibly only in the host for a part of their life cycle.

Although mosquitoes are not hosts to the new strain of yellow fever virus, it is not necessary to destroy its only other known hosts, human beings, in order to prevent its spread. In 1937 a vaccine, Virus 17 D, was developed in the laboratories of the International Health Division of the Rockefeller Foundation, after a period of experimentation with monkeys. By the end of 1937, 40,000 persons had been vaccinated with Virus 17 D; at the end of 1938 the number vaccinated had reached 1,059,252. During the year only eight cases of yellow fever developed among persons who had been vaccinated, and in six of these cases the onset of the disease was within four days of vaccination. The immunity is believed to be effective for at least a year, perhaps longer.

In his "Review" of the work of the Rockefeller Foundation for 1938, Dr. Raymond B. Fosdick suggests that conquering disease may be a moral equivalent of war. Certainly those who spend a large part of their lives in Brazilian jungles have high adventure. They learn what it is to remain steadfast during long periods of uncertainty; they taste of defeats as well as of victories. They burn with that restless energy that is leading man to control all the world except himself. Often they, too, stand at a Thermopylae or a Karelian Isthmus.

F. R. M.

THE SCIENTIFIC MONTHLY

OCTOBER, 1940

CANCER AND OLD AGE

By Dr. THOMAS PARRAN

SURGEON GENERAL, U. S. PUBLIC HEALTH SERVICE

THE cancer problem looms large in any consideration of the public health aspects of old age. The problem merits emphasis at present, because, on the one hand, cancer is a disease predominantly (though not exclusively) of old age, and on the other, the proportion of old people within the total population is increasing annually and progressively.

It is hardly necessary to point out at the beginning of this discussion that there are wide gaps in our knowledge of cancer; that fundamental causes of malignant growths are unknown or at least imperfectly understood; and that hence, a consideration of such a topic as the relationship between cancer and old age must take into account these gaps and deficiencies in our knowledge.

On the other hand, there is a substantial body of factual data which has been developed in relatively recent years (coming from such diverse fields as biology, biochemistry, biophysics, epidemiology and clinical medicine) from which there is emerging a general philosophy of cancer even though certain fundamental details of the picture remain, as yet, obscure.

Perhaps one of the most significant single components of the modern philosophy of cancer is the concept of the multiple character of the disease.

For many years cancer research was concerned largely and quite appropriately with such expressions of the disease as were found to be commonly associated with cancer of all anatomical sites. During the latter part of the nineteenth century, for example, cancer research was devoted almost exclusively to detailed study of the morphology of tumors, classification of cancer into separate histologic varieties, and the description of features generally applicable to all of its clinical and histologic forms. This contributed to the establishment of certain "criteria" of malignancy such as capacity for unrestrained growth, invasiveness and metastasis.

In the tumor research of more recent years, emphasis has shifted to more specific considerations of etiology. With the extension of knowledge thus acquired and with increasing consideration of the disease from the point of view of its broader—more especially its mass—manifestations, cancer is becoming differentiated into increasing numbers of separate entities. Thus present students of the problem have come to regard the diversity with which this large group of conditions we speak of as cancer expresses itself as being equally as striking and significant as the few characteristics generally regarded as common to it.

Even in these common characteristics, cancer of different anatomical sites and

histologic types shows striking variations. Various cancers or malignant tumors show remarkable differences in their functional capacities, their invasive qualities, the rapidity with which they grow, spread, and metastasize and their vulnerability to such physical agents as x-rays and radium. Considered from the point of view of its epidemiology, of various extraneous and environmental factors contributing to its etiology, of its geographical, racial, sex and age distribution, cancer presents a picture, not of a single entity, but of a group of more or less related conditions, the number of which is scarcely limited except by the number of organs and tissues which it attacks.

Thus, for a more thorough understanding of the relationship between cancer and old age, it will be necessary ultimately to consider each anatomical site of cancer separately, especially as regards its age distribution and also the variety of factors contributing to its etiology.

For an insight into the age distribution of cancer, excellent data are now available, some of the most extensive of which are in the records collected during recent years by the U. S. Public Health Service as a part of the general program of investigations of the National Cancer Institute. During the past two years surveys of cancer incidence have been made by the Public Health Service, covering the adjacent counties and cities of Philadelphia, Pittsburgh, Detroit, Chicago, Atlanta, Birmingham, New Orleans, Dallas, Fort Worth, Denver, and the San Francisco Bay region. In these surveys records have been obtained which show the age, sex, color, residence and primary site of disease of all cancer patients who came under the observation of the reporting physicians, clinics and hospitals within the communities, during the one-year period immediately preceding the survey.[1] For purposes of showing the age distribution of patients, the data which have been analyzed for all the communities except New Orleans, Philadelphia, Birmingham and Denver are available. These data cover the records of a total of 38,544 persons and relate to malignant tumors of every histologic type and anatomical site. The two accompanying tables are included for purposes of brief summary.

TABLE 1

THE AGE DISTRIBUTION OF PERSONS WITH CANCER (ALL FORMS) REPORTED FROM SELECTED COMMUNITIES IN THE UNITED STATES, 1939

Age of persons	Cases of cancer—all forms	
	Number	Per cent. of total
0–9	182	0.5
10–19	299	0.8
20–29	892	2.3
30–39	3016	7.8
40–49	7794	20.0
50–59	9935	25.7
60–69	9651	25.0
70–79	5474	14.2
80–89	1213	3.1
90 +	88	0.2
Total	38,544	99.6

Table 1 shows the age distribution of the thirty-eight and one-half thousand persons reported as having malignant tumor and including persons of both sexes and all races. It will be noted that almost exactly half of the total persons fall within the age group 50–69 years. A fifth of the patients are in the group 40–49 years, and an almost equal number at ages over 70. It is of some special interest to note that one out of ten of these patients is under 40 years of age. The data in this table merely confirm the results of repeated observations elsewhere, namely, that the bulk of cancer is found in late adult life and old age.

However, it should be emphasized that

[1] As evidence of the cooperative spirit of the medical groups in these communities, it should be noted here that all of the clinics and hospitals, and more than 95 per cent. of the practicing physicians made returns in these surveys.

these data show only the over-all picture of cancer and do not portray the differences which actually exist as between the two sexes, different races and different anatomical sites of the disease. While a more detailed consideration of the subject would necessarily take all of these factors into account, it is believed that for present purposes the data in Table 2 will suffice. This table shows the distribution in broad age-groups of persons with cancer of certain selected anatomical sites. The second column of the table shows the number of persons with cancer of the various sites merely to indicate the statistical reliability of the percentage figures. The data refer to the principal (but by no means all) sites of cancer. The sites, as listed, are arranged in the order of their relative frequency in persons under 30 years of age. Except for skin, lip and rectum, the order of arrangement in the column "Under 30" is almost the reciprocal of that in the column "70 and over."

TABLE 2

THE AGE DISTRIBUTION OF PERSONS WITH CANCER OF CERTAIN ANATOMICAL SITES

Primary site of cancer	Cases of cancer of selected sites					
	Total number	Percentage in persons at ages				
		Under 30	30–49	50–69	70 and over	Total
Bone	594	26.9	29.7	37.4	6.0	100.0
Uterus	5818	2.7	41.2	48.3	7.8	100.0
Skin	5101	2.6	20.4	49.8	27.2	100.0
Lip	1364	2.2	30.0	51.1	16.7	100.0
Rectum	2107	2.2	24.0	56.2	17.6	100.0
Lung	939	1.8	30.4	57.7	10.1	100.0
Breast (female)	5980	1.6	36.6	49.9	11.9	100.0
Larynx	471	1.2	21.9	64.0	12.9	100.0
Stomach	3014	0.8	19.2	57.8	22.2	100.0
Bladder	1265	0.6	17.8	55.8	25.8	100.0
Prostate	1432	0.2	3.4	50.1	46.3	100.0

As compared with cancer of all sites, malignant tumors of the bone and the uterus show an excessive prevalence in relatively young persons; cancer of the lip, rectum, lung, larynx and female breast tends to be concentrated in the third to sixth decades; cancer of the stomach, bladder and prostate occur with much greater frequency after the fifth decade (showing very high frequencies at ages 70 and over); and cancer of the skin is somewhat more evenly distributed throughout the life-span (ranking third in relative frequency at ages under 30, and second at ages 70 and over).

From the data presented above, it is clear that cancer is a disease predominantly of late adult life, but by no means exclusively so. Thus one may postulate a correspondingly predominant, but by no means exclusive, role for the aging processes of the tissues of the host as a contributing factor in the genesis of cancer.

Most students of the disease view the etiology of cancer as coming within two more or less broad categories: (1) Extraneous and environmental factors, most of which are endowed with properties for producing chronic irritation; and (2) factors inherent in the human host.

Extraneous factors surrounding the development of the disease are believed to be variously combined for practically all malignant tumors. Certain combinations of these factors are already known to be quite distinctive for various cancers. The best examples of distinct etiologic agents are found in occupational cancer such as skin cancer in oil and paraffin workers, skin cancer of sailors and farmers who have undergone many years of excessive exposure to sunlight, x-ray cancer, cancer of the bladder in persons engaged in the handling of anilin dyes, scrotal cancer in chimney-sweeps, and cancer of the lung in cigar-makers, weavers, and those employed in certain mine operations.

Other examples of commonly associated extraneous factors with cancer genesis are to be found in the lip cancer of pipe smokers, the Kangri and betel-nut cancers of certain tribes in India, cancer of the tongue in persons with

irregular jagged teeth, skin cancer superimposed upon the sites of ulcers, burns, chronic sinusitis and with Paget's disease of the nipple. Certain cancers, particularly of the bone and testicle, appear frequently to have a traumatic origin.

In connection with the above, it may be pertinent to mention the extraordinary fact of the extreme rarity of cancer of the penis among persons circumcised during infancy, in contrast to its relative frequency among the uncircumcised. Of special interest is the observation that the disease is almost never encountered among Jews who are circumcised during infancy, but is relatively common among Mohammedans, for example, among whom circumcision is almost universal, but at a later age, usually around puberty. This phenomenon conceivably might be explained on a basis of a racial immunity in the Jew, but such an explanation would require the postulate of a specific organ immunity in view of the frequency with which cancer of all other organs and tissues is found in the Jew.

In the light of existing knowledge, no concept of cancer genesis is reasonable which does not postulate some etiological significance to factors inherent in the human host. Certain malignant tumors may be ascribed reasonably to processes of chronic irritation acting upon normal cells. On the other hand, it is difficult to reconcile the peculiarities of development of many cancers with any point of view which does not assume the existence of local tissue predisposition; and there are still other tumors in which a constitutional predisposition toward their development appears to be of real significance.

The importance of these factors of host susceptibility and tissue predisposition is extremely difficult to measure. Such factors are too subtle and present methods of observation too crude to bring them into focus and permit a quantitative assessment. Some of them, suggested through clinical observations, tend to be confirmed in the experimental laboratory; others are merely suggested, and confirmation must await further studies in clinical, epidemiological and experimental fields.

Examples of predisposing factors are found in the assumption of cancer genesis from isolated embryonal cell groups, from the persistence of tissue which normally regresses after embryonal life, from developmental defects of organs and tissues, from conditions of imbalance of endocrine gland activity, especially as related to sex hormones, from conditions associated with overnutrition, from conditions regarded as hereditary or congenital, and finally from factors inherently associated with race, sex and age.

Just as it has been impossible to give relative values to the importance of the "seed and the soil" in human tuberculosis, so is it difficult to assess the relative significance of extraneous and "endogenous" factors in human cancer. This is especially so when the "aging process" is included as one of the "endogenous" factors for appraisal.

Most evidence at hand, especially that arising out of clinical experience, emphasizes the long interval between exposure to extraneous factors and onset of malignant tumor. This evidence is particularly notable in cases of occupational cancer where exposure to occupational hazard antedates by many years the onset of the disease. It is not unusual, for example, to find cancer of the bladder developing among dye workers more than a decade after such persons have discontinued their employment. If the immunity of the Jew to cancer of the penis may be ascribed to circumcision during infancy, and the fact accepted that circumcision at puberty affords no such protection for the Mohammedan, the

inference may be justified that whatever the cancer-exciting factor may be (as related to the absence of circumcision), it requires a long period of latency to express itself in clinical disease.

The necessity for taking into account this long interval of "incubation period" adds materially to the complexities of cancer research. For a better understanding of the peculiarities in the age distribution of cancer it will be necessary ultimately to resolve many questions, the answers to which are unknown at present: For example, is old-age cancer merely a function of long time action required by the exciting etiologic agent, or are there factors associated with the aging process itself which alter the tissues of the host so as to make them increasingly susceptible to malignant changes with advancing age? If the phenomenon is essentially a function of the aging process, how can one distinguish between physiological and chronological age? What are the physiologic characteristics of aging? And finally how can they be modified? An effort to resolve such fundamental questions as these is a challenge to modern cancer research.

We need to know more about the fundamental principles underlying growth itself; studies must be encouraged in clinical and epidemiological fields in an effort to define more specifically and measure more accurately the variety of extraneous factors contributing to the etiology of cancer. More information on the aging process itself should contribute in a remarkable way to a better understanding of the cancer problem.

Although much remains to be learned about the basic causes of cancer, and hence interpretations of such causes, in the light of existing gaps in knowledge, necessarily are, to a certain extent, speculative, the public health implications of the cancer problem in an aging population are none the less real or significant.

Most students of population, assuming a "conservative" immigration policy and reasonable mortality and fertility rates, estimate that the population of the United States will have reached a peak (somewhere near 160,000,000) during the next 40–50 years. They are agreed also that a change in the age distribution is a fundamental feature of these population trends. It is estimated that 40 years hence there will be approximately an equal number of persons (two million) at each year of age from birth to 60 years. Although there will be a smaller number of persons at later ages, these will form a much larger proportion of the total than at present. According to these estimates, 15 per cent. of the population in 1980 will be over 65 years of age as contrasted with a little more than 6 per cent. at present and only 4 per cent in 1900.

Thus there can be no serious question as to the significance of the future cancer load in the United States when it is realized that during the next 30–40 years the population of the country 55 years of age and over, who now contribute annually 5 deaths from cancer out of every 1000 living, or among whom 12 out of every 100 deaths from all causes are due to cancer, will have reached approximately 40 million.

On the basis of numbers alone, the potentialities of the cancer problem are enormous. However, any well considered plan for meeting the problem in the future must take into account the fact that an aging of the population not only increases the number of the aged, but also impinges in a variety of ways upon the economic, social and cultural patterns of the country. The urbanization of the population may well contribute factors both favorable and unfavorable to the cancer situation—unfavorable by

reason of environmental hazards contributing to cancer genesis—favorable by virtue of increased opportunities for the provision of facilities for clinical cancer service and research: The rapid tempo of social changes may likewise influence the problem through the accompanying complexities of living and artificiality of foods: The regional distribution of population density, the geographical distribution of industrial employment and technological progress in industry and agriculture may all be worthy of consideration in view of the known geography of cancer and the industrial origin of many of its forms. Finally, since the control of cancer depends largely upon facilities for diagnosis and treatment, the problem can not be divorced from broader considerations of general medical service and the way in which these considerations will find expression in a national health policy.

Public Health, like all other segments of public service, is profoundly concerned with the social and economic changes incident to the aging and growth of the population. This concern can be expressed most effectively by Public Health through an attempt to study and anticipate these changes, and, on the basis of experience and knowledge thus acquired, direct its own efforts in harmony with them and in whatever manner possible exert its influence toward guiding them in a constructive way.

As regards cancer, obviously the first challenge is to extend our frontiers of knowledge of the causes of the disease and of methods for its control; the second requirement, which is equally as challenging, calls for the application of such knowledge in the most effective way and through facilities, procedures, and methods of organization in harmony with the spirit of constructive public service.

THE DARWINIAN THEORY AND RELIGION

It would be impossible for any one to discuss in a fair and intelligent manner the great question of the origin of species, in anything less than a bulky volume. The merest mention is, therefore, all we can give to it at the present time. Although the appearance of Darwin's book on the "Origin of Species" communicated a distinct shock to the prevalent creeds, both religious and scientific, the hypothesis which it suggests, though now for the first time distinctly formularized, was by no means new; as it enters largely into the less clearly stated development theories of Oken, Lamarck, De Maillet, and the author of the "Vestiges of Creation." There was this difference, however, that in the developmental theories of the older writers the element of evolution had a place; the process of development had its mainspring in an inherent growth, or tendency, such as produces the evolution of the successive parts in plant-life, while, according to Darwin, the beautiful symmetry and adaptation which we see in nature is simply the form assumed by plastic matter in the mould of external circumstances.

Although this Darwinian hypothesis is looked upon by many as striking at the root of all vital faith, and is the *bête noire* of all those who deplore and condemn the materialistic tendency of modern science, still the purity of life of the author of the "Origin of Species," his enthusiastic devotion to the study of truth, the industry and acumen which have marked his researches, the candor and caution with which his suggestions have been made, all combine to render the obloquy and scorn with which they have been received in many quarters peculiarly unjust and in bad taste. It should also be said of Mr. Darwin that his views on the origin of species are not inconsistent with his own acceptance of the doctrine of Revelation; and that many of our best men of science look upon his theory as not incompatible with the religious faith which is the guide of their lives, and their hope for the future. To these men it seems presumption that any mere man should restrict the Deity in His manner of vitalizing and beautifying the earth. To them it is a proof of higher wisdom and greater power in the Creator that He should endow the vital principle with such potency that, pervaded by it, all the economy of nature, in both the animal and vegetable worlds, should be so nicely self-adjusting that, like a perfect machine from the hands of a master maker, it requires no constant tinkering to preserve the constancy and regularity of its movements.—*From an address by J. S. Newberry (1822–1892), delivered as retiring president of the American Association for the Advancement of Science at its annual meeting in Burlington, Vermont, in August, 1867.*

ERRORS IN SCIENTIFIC METHOD—GLACIAL GEOLOGY

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Early Explanations of the Drift

Wide-spread over northern North America and Europe lie the direct deposits of continental ice-sheets, the boulder-clay or till; and along with these the gravels and sands left by the waters which everywhere accompanied the melting of the ice. There was no correct understanding of this material, called "drift," until after Agassiz's work, or about 1840. In the absence of such an understanding, how did the early geologists explain the drift? They could not fail to notice it, especially the erratics, immense blocks often far from their original ledges and in positions hard to account for.

To understand the difficulty of the situation it is necessary to have certain facts in mind. We are living to-day in the closing stages of a glacial period. To be sure, the great ice-sheets of northern America and Europe are gone. But glaciers still occur in the mountains, even under the equator. The snow line gets lower and lower toward the poles, until we find valley glaciers entering the sea in Chili and southern Alaska. An ice-cap some 700,000 square miles in area covers Greenland, and the Antarctic ice-cap is estimated to have an area of over 5,000,000 square miles. Daly estimates the ratio of present ice to that of the maximum of the last or Wisconsin ice-sheet as one to three. Clearly we are not yet "out from under." Nor can anyone foretell the future. It would not be geologically unprecedented if the ice-sheet were to return, and, moving south from Canada to something like its former limit, wipe out all human construction in the populous area of northeastern United States.

We are living in an exceptional period, geologically speaking. Throughout most of the earth's past, glaciers were non-existent and mild climates extended well toward the poles. Suppose man had made his appearnce a bit later than he actually did, not during the last stage of the ice period but after its close, when the climate was again mild and all glaciers had disappeared, even from the mountains and the polar regions. He would have had before him all the effects of the former glaciation, the glaciated surfaces, boulder clays, erratics, moraines, etc., but the agencies he would find at work would be nowhere producing such effects—neither winds, rivers nor waves. He would be at a complete loss for an explanation of them.

In the absence of any true explanation of the drift, what explanations were offered? There were numerous guesses, but the ones most widely adopted were either some catastrophe or convulsion of nature, usually the Noachian deluge, or, more conservatively, floating ice.

Consider first the hypothesis of catastrophe. Geology was in its infancy. The ordinary geological agencies, especially stream erosion and deposition, had not been studied in detail, and there was little appreciation of the large results of slow processes working through long periods of time. Indeed there was no general belief that the earth's history was long; lack of knowledge, plus the generally accepted Genesis account of the earth's origin, made it natural to assume that its history was short. At the same

time, even a slight acquaintance with the disturbed rocks of the earth's crust showed that stupendous changes had taken place. The combination of these two views meant catastrophism, the belief that geological history was a series of convulsions.

As an example of catastrophic explanation we may quote Saussure's Explanation of the Origin of Rolled Pebbles (and erratics?) (1787): "When the waters of the ocean in which our mountains were formed still covered these mountains, a violent earthquake suddenly opened great cavities that had previously been empty. The waters rushed toward the abysses with extreme violence, proportionate to the elevation that they then had, cutting deep valleys and sweeping along immense quantities of earth, sand and fragments of all sorts of rock. This semi-liquid heap, pushed by the weight of the waters, piled up to the heights where we still see many of these scattered fragments. Then the waters, continuing to flow with a rapidity which diminished gradually in proportion to the diminution of their elevation, swept away the highest parts, little by little. They purged the valleys of this heap of mud and débris, leaving behind only the heavier masses and those whose position or more solid state protected them from this action." For unchecked speculation this would be hard to beat, but it should be remembered that Saussure has large and solid contributions to geology to his credit.

There was one available catastrophe right at hand in the Biblical deluge, generally accepted as fact by both layman and scientist, when "all the fountains of the great deep were broken up, and the windows of heaven were opened . . . and all the high mountains that were under the whole heaven were covered." Given this situation, anything might happen and it was easy to explain the drift. Silliman (1821) admitted that the drift was "very inadequately accounted for by existing theories," and wrote (1824), "No one will object to the propriety of ascribing very many, probably most of our alluvial features, to that catastrophe—the deluge of Noah." He himself suggested "enormous caverns in the bowels of the earth—which collectively, or even singly, might well contain more than all our oceans. . . . If these cavities communicate in any manner with the oceans, and are (as, if they exist at all, they probably are) filled with water, agents very competent to expel the water of these cavities, and thus to deluge, at any time, the dry land are at hand." Pages of similar views, often by men of high scientific standing, could be quoted; it would only witness to the control of tradition, and to the extremes to which even able men would go, in order to explain the inexplicable. It is not easy to say "I do not know."

A saner explanation of the drift was that it was brought to its present position by floating ice at a time when large sections of northern Europe and America were beneath the sea. This theory appealed to existing agencies, for both icebergs and shore ice were known to transport rock debris, and could be checked. Lyell's first edition of the "Principles of Geology" was published in 1833, and in it he seems to look the drift steadily in the face and pass by—a not uncommon way of meeting difficulties. In the first edition of the "Elements of Geology" (1838), published when Agassiz was beginning his studies, Lyell does not distinguish, among surface deposits, between residual soils, glacial till, and waterlaid sands and gravels. He does consider glaciated surfaces, and especially the erratics, and appeals to floating ice at a time when the sea stood at a higher level with reference to the land. "Icebergs then, detached from glaciers, together with coast ice, may convey for hundreds of miles pebbles, boulders,

sand and mud, and let these fall wherever they may chance to melt, on submarine hills and valleys. These, when the land emerges from the deep, may constitute some of the far-transported alluvium which has been ascribed to diluvial agency." To this explanation of the lowland drift Lyell clung for several decades.

If—Then, or Faulty Method

How was scientific method applied to these early theories? So far as concerns the catastrophe and deluge explanations, it just was not applied. The iceberg theory, however, is serious science, and it will pay to study its treatment.

Science advances by the solution of problems. The proposed solution of any problem we call an hypothesis. The thing to do with an hypothesis is not to accept it as true, but to test it in order to verify or invalidate it. *If* the hypothesis is true, *then* certain things follow. Verification of an hypothesis consists first in the skilful development of its implications, and then in the often long and hard work of checking such implications. The hypothesis may flash on the mind which is prepared, from no one knows where. The verification may take months or years.

The problem we are considering is the origin of the drift, of which the erratics are the most conspicuous feature. Lyell's hypothesis was that the drift was brought to its present position by floating ice. This necessitated extensive land submergence. What were some of the implications of the hypothesis, and how should the geologist have gone about testing it? If the hypothesis were correct, there should be independent evidence of land submergence, as suggested under the following points:

(1) The nature of the drift. If the drift was laid down in marine waters it should be stratified and contain marine fossils. Students were thrown off here, because there is almost everywhere stratified material associated with the drift, not only over its surface, but throughout its mass,—sands and gravels due to the melting waters of the glacier. Hence it was easy to believe that the whole mass had one origin and was waterlaid. In the absence of any competing theory of direct ice deposition, and so of any attempt to develop deductively criteria of deposits of differing origin, fine unstratified clays, often many feet thick, with scattered boulders of all sizes and practically without fossils, were unthinkingly accepted as waterlaid.

(2) The amount of submergence required is important. It must have been at least as deep as the height of the highest continental (as distinguished from mountain glacier) drift and rock scorings above the present sea-level, which is several thousand feet. This should have put a severe strain on the hypothesis.

(3) The limits of the drift should by hypothesis have been the limits of the water bodies in which the drift was dropped by floating ice, and should be marked by the characteristic features of wave action, by cliffs, beaches, etc. No such inference was made, and no such evidence sought; had it been sought it would not have been found, for it does not exist. There are, indeed, shore features which mark lower land-levels and the borders of temporary lakes, but they are within the area of the drift and not about its border; they do not reach heights above sea-level at all comparable with those of the higher drift, and they rest on the drift and are later than rather than contemporary with it.

(4) A further question might have suggested itself: Are the scorings on the bedrock of the kind drifting ice would make? It would be hard to explain the parallel flutings of the typical glaciated surface as due to the accidental grounding of floating ice.

Such are some of the implications of

the iceberg hypothesis which might have suggested themselves under a somewhat rigorous application of the scientific method. The evident conclusion would have been that the drift was not brought by floating ice. That would have left the geologists of the time without any valid explanation of the phenomenon.

Agassiz, Father of Glacial Geology

It was Louis Agassiz, Swiss biologist, who one hundred years ago started glacial geology on its career when he used the summer vacation of 1836 to go with his friend Charpentier into the upper Rhone valley to study its glaciers. Charpentier believed in a former vastly greater down-valley extension of the Alpine glaciers. Agassiz went a sceptic but returned a convert. Together the two men tracked the former courses of the glaciers by the polished and grooved surfaces of the bedrock and by the debris, down the mountain valleys and out across the broad valley of northern Switzerland to the slopes of the Jura. Though Agassiz continued field work through successive summers until the eve of his migrating to America in 1846, the whole matter of the former greater Alpine glaciation was worked out in that first summer; and in the fall of 1837 Agassiz outlined the whole subject in masterly fashion in his presidential address before the Helvetic Society of Natural History. The work of the later seasons dealt largely with the physics of the glacier, which does not concern us here.

It was one thing to demonstrate the former greater extension of the present glaciers of the Alps; it was quite something else to show the former existence of glaciers in a country where there are none to-day. In 1840 Agassiz visited England, and, with Buckland as his guide, found in the Highlands of Scotland, in the Lake District of northern England and in Wales, glaciated surfaces and glacial moraines similar to those with which he had become well acquainted in the Alps. In November of that year he presented his evidence before the Geological Society of London.

Agassiz's two volumes on glaciers, "Études sur les Glaciers" and "Système Glaciare," were published in 1840 and 1846. In America, after 1846, his zoological work claimed almost all his time, but he never lost interest in his glacial geology. He noted evidences of former glaciation in New England and New York, and he occasionally spent some time in the field, as in Maine in 1864. In 1866 in Brazil, he thought, mistakenly, that he had found evidence of ice action; and in 1871, only two years before his death, on his voyage in the *Hassler* to South America, he met his old friends the glaciers along the Straits of Magellan and on the southern coast of Chile.

How come it that Agassiz, Swiss biologist, is known as the "father of glacial geology"? This double-barrelled question, why a Swiss? why Agassiz? requires a double answer.

Why a Swiss? Geology differs from most sciences in that its investigations are geographically determined. Rocks vary greatly from place to place, in age, in structure and in surface expression; and the phenomena of geology have to be studied where they are found. It was no accident that stratigraphic geology took its rise in central England under William Smith; and with Cuvier and Broignart in the Paris basin, where gently inclined beds shingle out on the surface in such wise that the order of vertical succession is easily seen. The great contributions to pre-Cambrian geology were made by the geologists of Canada, the northern United States and Scandinavia, working in the great Canadian and Scandinavian pre-Cambrian areas. Glacial geology has inevitably had its beginnings in a region of existing glaciers, the Alps. There are, of course, glaciers in other

parts of the world; in Alaska, Chile, India, Greenland, Antarctica; but in 1836 these regions were practically unknown, far removed from any center of scientific activity. The Alps were near at hand and accessible. If there was to be a father of glacial geology, the odds were heavily in favor of some scientist living near their borders; he might have been German, Austrian, French or Swiss. Actually he was a Swiss.

Why Agassiz, the zoologist? It was partly chance, but more the man. Suppose he had taken that vacation at the shore? Apart from chance, it was largely Agassiz's personality. Agassiz was not the first to appreciate the evidence of former greater glaciation. The German Kuhn had seen it as early as 1787. So had Venetz in 1821, Bernhardi in 1832, and Charpentier had the whole matter correctly in 1834. Indeed, it was Charpentier who introduced Agassiz to the glacier. But put a man of boundless physical and mental energy on a problem, and no one can tell how far he will go. Agassiz was twenty-nine, in the full strength of early manhood, when he began his glacial studies, a fiend for work. "The day ought to have thirty-six working hours," he complained. He was doing full-time zoological and paleontological work and printing the illustrations of his works, when he took on this additional glacier problem. He was an ardent pedestrain, and in the Alps "delighted in feats of walking and climbing." His wide-ranging philosophical views of nature at once connected his field studies with extensive recent changes in life and in continental development. Add to this energy and enthusiasm the fact that throughout life Agassiz was a man of great personal charm and an eloquent speaker, and it is easy to see how, without consciously intending it, he stole the whole show. It was not that he appropriated or disparaged the work of his predecessors, for he did not. Rather, his energy, enthusiasm, and the charm and skill of his presentation swept the field.

Agassiz's Errors

Agassiz's work on glacial geology is not without admixture of error, and it is instructive to note the sources of these errors. To a very limited extent they concern minor items in his description and interpretation of field facts. "Erratic blocks of the Jura . . . reposing on a bed of cobbles and pebbles . . . well-rounded and heaped in such fashion that the largest are on the top, while the smallest, which grade to a fine sand are occupying the base and resting directly on the polished surfaces"[1] does not read like an adequate description of the drift. Careful petrographic study of the drift had not begun. Agassiz's major mistakes, however, did not arise from the direct interpretation of immediate field facts; they came from speculations going well beyond any legitimate inferences from his own field work. In his earlier writings he assumed:[2]

(1) Polar ice-caps in both hemispheres, the northern ice-cap extending south and covering Asiatic Russia and Europe to beyond the Mediterranean, and all of North America.

(2) That at this time the Alps had not been elevated.

(3) That with the elevation of the Alps "this ice formation was raised like the other rocks; the fragments broken from all the crevices during the upheaval fell on its surface and without being . . . rounded moved down this great sheet of ice."

(4) "As the ice melted, it formed great funnels in the places where it was thinnest; valleys of erosion were cut in the bottom of crevasses in localities where no stream could exist without being encased in walls of ice."

[1] K. Mather and S. L. Mason, "Source Book in Geology," p. 232, 1939.

[2] *Ibid.*, p. 334.

To polar ice-caps Agassiz long adhered. He writes in 1866: "Two vast caps of ice stretched from the northern pole southward, and from the southern pole northward, extending in each case far toward the equator."[3] Centering the ice-caps at the poles was a not unnatural mistake. In Europe the direction of the ice movement was in general to the south, northern Europe and America were unknown, and years of field work were necessary before it could be shown that the glaciers moved radially out from land centers—in Europe from Scandinavia, in Canada from Labrador and from the Great Plains west of Hudson Bay. His statement, of course, carries the southern limit of the ice-cap too far to the south.

While the mistake just mentioned was due to speculation which ran ahead of any available field evidencce, items 2 and 4, which are more poetry than science, rest back on a basically false scientific philosophy, uncritically assumed by one who was temperamentally inclined to wide-ranging theories. Darwin's "Origin of Species" was not to be written for nearly a generation. Lyell's uniformitarianism, the doctrine that the earth's past history is to be explained by present agencies of change acting at essentially present rates, had little hold on scientific men. Genesis was still considered in many quarters good science. If, according to Genesis, time was short, and, according to geology, great changes had been frequent, catastrophism was a necessary conclusion. Agassiz belonged to this school of thought. Writing as late as 1866 he held that "a sudden intense winter, that was to last for ages, fell upon our globe . . . and so suddenly did it come upon them (tropical animals), that they were embalmed beneath masses of snow and ice, without time even for the decay which follows death."[4] In such fashion he accounts for the woolly mammoth mired in the soils of northern Siberia. This doctrine of catastrophe found supposed scientific warrant in the writings of Cuvier (1769–1832), who gave it expression in his "Révolutions de la Surface de la Globe" (1825). Cuvier's scientific reputation gave his opinion in this matter a weight beyond any warranted by the facts; and Agassiz, who as a youth had worked in Cuvier's laboratory and was his life-long admirer, doubtless was influenced by the older man. Certainly the statements, 2 to 4 above, have little reference to actuality.

Let no comments on Agassiz's errors discredit his solid contributions to geology. He it was who started glacial geology on its course. He was a land-ice man from the beginning to the end. It is credit enough to be the father of glacial geology. If the father made occasional mistakes in bringing up his offspring, what father does not?

The Reception Given the Glacial Theory

The glacial seed fell on soil both fertile and stony. Edward Forbes wrote Agassiz (1841):

> You have made all geologists glacier-mad here, and they are turning Great Britain into an ice-house. Darwin, who was both geologist and biologist, applied the new views to the explanation of field facts in North Wales. Lyell (1840) presented a paper "On the Geological Evidence of the Former Existence of Glaciers in Forfarshire."

Others opposed, some, like von Buch, violently. Humboldt wrote Agassiz, "Your ice frightens me." Not unnaturally, when it is remembered that Agassiz's views included not only greater Alpine glaciers and former glaciers in regions not now glaciated, but immense polar ice-caps covering much of the lowlands of Europe and America. Murchison (1842) wrote,

> Once grant to Agassiz that his deepest valleys of Switzerland, such as the enormous Lake of Geneva, were formerly filled with snow and ice,

[3] "Geological Sketches," p. 212.

[4] *Ibid.*, p. 208.

I see no stopping place. From that hypothesis you may proceed to fill the Baltic and the northern seas, cover southern England and half of Germany and Russia with similar sheets. . . . So long as the greater number of the practical geologists of Europe are opposed to the wide extension of a terrestrial glacial theory, there can be little risk that such a doctrine should take too deep a hold on the mind. The existence of glaciers in Scotland and England (I mean in the Alpine sense) is not, at all events, established to the satisfaction of what I believe to be by far the greater number of British geologists.

And later (1849) he wrote Agassiz,

When are we to have a "stand-up fight" on the erratics of the Alps? . . . In a word I do not believe that great trunk glaciers ever filled the valleys of the Rhone, etc.

The successive editions of Lyell's "Principles of Geology" and "Elements (or Manual) of Geology" may be taken as giving the orthodox view of glacial geology. Before Agassiz, it is the iceberg hypothesis. For two decades Lyell refused to accept the Jura erratics as "part of the doings of Charpentier's great glacier," preferring to explain them by submergence and floating ice. In 1857 Lyell went to Switzerland, "being desirous to see the proof with my own eyes." He then wrote, "the entire absence of marine remains in the associated (rocks), the conformity of the distribution of the travelled blocks here with the shape of so many valleys, and above all, the sight of the Alpine snows . . . has made me incline strongly to embrace the theory of a terrestrial glacier";[5] and he did! For an explanation of general lowland glaciation, however, Lyell clung almost, if not quite, to the end (he died in 1875), to the iceberg hypothesis. There is an inconclusive reference to the "Greenland continental ice,"[6] but one looks in vain in the last editions of Lyell's works for any clear recognition of land ice in the great glaciated areas of Europe or America.

[5] "Life of Sir Charles Lyell," Vol. II, p. 250, 1881.

[6] "Students' Elements of Geology" (Seventh ed.), p. 170, 1871.

It may help us to understand Lyell's conservatism if we consider that he was forty when, in 1837, Agassiz first proposed his land-ice theory, and then recall a statement of Darwin's concerning Lyell in his own "Autobiography," "When I made any statement to him (Lyell) on geology, he never rested until he saw the whole case clearly. . . . He would advance all possible objections to my suggestion, and even after these were exhausted, would long remain dubious."

For some reason the Americans seem to have been more open-minded. Dana's "Manual" contrasts favorably with Lyell's "Principles" and "Elements." Dana writes, "In view of the whole subject, it appears reasonable to consider that the glacier theory affords the best and fullest explanation of the phenomena over the general surface of the continents, and encounters the fewest difficulties. But icebergs have aided beyond doubt in producing the results along the borders of the continents, across ocean channels like the German Ocean and the Baltic, and possibly over great lakes like those of North America. Long Island is so narrow that a glacier may have stretched across it."[7] In his second edition Dana sets forth the two theories, with reasons for and against, abandons the iceberg hypothesis completely and concludes, "It hence appears that the glacier theory is alone capable, as first shown by Agassiz, of explaining all the facts."[8]

Still, some American geologists fought against the theory to the end. Sir William Dawson, in his "Acadian Geology" (edition of 1878), and later in 1893, argued against it.[9] Among the reasons he gave were the following:

[7] "Manual of Geology" (First ed.), p. 346, 1863.

[8] "Manual of Geology" (Second ed.), p. 537, 1874.

[9] Summarized by G. P. Merrill, "Contributions to the History of American Geology," Rept. U. S. National Museum for year ending June 30, 1894, pp. 521, 573, 1896.

(1) The temperate regions could not be covered with a permanent mantle of ice, under existing conditions of solar radiation.

(2) It was physically impossible for a sheet of ice to move over an even surface and striate it in uniform direction over wide areas.

(3) Glaciers could never have transported the large boulders and left them in the positions where they are now found, for they are often at higher levels than the ledges from which they came, and anyhow, as no rock masses rose above the surface of the supposed glacier, there was no source from which they could have been gathered!

One wonders at the method of approach; this setting up a priori objections against field facts, rationalistic argument in preference to holding close empirically to the field evidence. It raises an interesting question in logic; when reasoning shows that an event could not have taken place, and a reasonable interpretation of field evidence shows that it did, which is one to believe? As late as 1893 Dawson was assuming former submergence of drift-covered areas, with currents sweeping down from the north, eroding valleys such as those of the Great Lakes, and carrying debris, including immense erratics, widely over North America. Newberry, commenting earlier on Dawson's views, says, "The difficulties in the way of this theory are such, however, that I am sure Professor Dawson, clear-sighted and conscientious as he is, would abandon it if he could examine with his own eyes the surface geology of the Lake-basin and the Mississippi Valley."[10]

How are we to account for the long delay of many geologists, including some of high standing, in accepting the theory of continental ice-sheets? Various suggestions may be given; and it is probable that in individual cases more than one reason functioned.

The true scientist is a natural skeptic; he doubts until he is compelled to believe. He would be untrue to his calling did he otherwise. Wherever his actual birthplace, he is "from Missouri" and has to be shown. Darwin's comment on Lyell, quoted earlier, is relevant here. Delay such as this is creditable.

In geology the facts are out in the field; one has to go out and find them, often in places not easy to get at. The opinions of the armchair geologists have little weight in comparison with the findings of the field geologist.

Hypothesis, while based on facts, also runs ahead of fact. To verify the hypothesis of continental glaciers in all its detail, long continued field study over wide areas, largely unsettled, was necessary. Some delay was unavoidable because of lack of evidence. This was not true, however, concerning the fundamental question whether the drift was ice or waterlaid. The evidence on that was abundant and immediately at hand.

Personal bias of various sorts plays its part. Traditional belief and authority have a larger influence in science than is usually admitted. Statements of supposed scientific fact are passed down from decade to decade, from text to text, until someone keener than the rest shows their falsity.

The scientific atmosphere of the time is an important, though usually an unconscious, influence. This was doubtless the source of Agassiz's catastrophism.

Then there is pride of opinion. Even a scientist may not want to admit his error if he has been prominently committed to a view. Darwin writes of himself:

> I had also during many years followed a golden rule, that whenever a published fact, a new observation or thought came across me, which was opposed to my general results, to make a memorandum of it without fail and at once; for I had found by experience that such

[10] "Geological Survey of Ohio," *Geology*, II: p. 27, 1874.

facts and thoughts were far more apt to escape from the memory than favorable ones. Owing to this habit, very few objections were raised against my views, which I had not at least noticed and attempted to answer.

This is the scientific conscience at its best.

There is also plain human inertia that stands in the way of the mental readjustment required by new fact and new theory. One can not put new wine into old wine-skins. Views to which one has grown accustomed seem natural: new views, strange and often wrong. Indeed, Agassiz himself, in his own field of biology, is an example of this unwillingness to accept new theories. Darwin's "Origin of Species" was published in 1859. Agassiz, until his death in 1873, was an active opponent of evolution. If one seeks an explanation, he enters on a study of personal bias and prejudice, due to the conflict of new views with other general and specific beliefs which had long been erroneously held as true.

We seem to have been giving the men of science pretty rough treatment? But this is only one side of the picture: the errors against which they must guard. On the other hand, no better delineation of the ideal scientist could be given than this, by Josiah Parsons Cooke, professor of chemistry for many years in Harvard College:

The great pioneers of science have been men of ideals, but men whose vivid imaginations were regulated by education, and chastened by wisdom. They have been men of courage and perseverance, who followed out their convictions through every discouragement. They have been men of entire truthfulness, who have never hesitated to submit their doctrines to the test of experiments and to abide by the issue. They have been men of the most scrupulous conscientiousness in attention to minute details, regarding themselves as responsible to the Giver of all truth for accuracy in every observation, and for exactness in every statement. Finally, they have been men of modesty and of reserve in judgment, realizing, as no other men ever have, how boundless is truth; how limited knowledge; how intricate the problems of nature; how weak in comparison the intellect of man.

One or More Glacial Periods?

A matter of the highest importance in glacial geology is whether there were one or more glacial periods. When Agassiz first showed the former greater extent of glaciation, it was of course natural to speak of *the* glacier and *the* glacial period; no other assumption was warranted. Later, forest beds and soils were found buried within the till, both in Europe and America, separating an upper and a lower till. This happened in Illinois in 1868, and soon after in Ohio and Minnesota. There were two possible interpretations of such discoveries. The advances and retreats of Alpine glaciers was common knowledge. Might not the continental ice sheet have retreated, and vegetation and even forests have grown over the surface of the abandoned drift, only to be overwhelmed and buried by the deposits of a readvance? If so, the two drifts would represent two epochs of a single ice period, the same glacier continuing in existence throughout the whole time. On the other hand, was it not possible that during the time between the two deposits the ice-cap disappeared from North America? There would then be two ice periods. An ideal place for solving the problem is the upper Mississippi valley, where the ice advanced to varying distances and the successive drifts can be easily studied. The work of McGee, Chamberlin, Salisbury, Calvin, Leverett and many others has shown that the lower and outer drifts are more deeply weathered and stream-eroded than the inner drifts; that where one overlies another the surface of the lower is often deeply weathered, and that fossil remains in the intervening beds indicate climates as warm as, or warmer than, that locality enjoys to-day. The longer and milder the intervening period, the more probable the disappearance of the preceding ice sheet from the continent. So the theory at first was—two separate glacial periods.

But it did not stop with two; continued detailed studies are now believed to show four glacial periods, separated by even longer interglacial periods, the time from the beginning of the first glaciation to the present time, which gives the length of Pleistocene or glacial time, being estimated at roughly a million years.

Now this is of the greatest importance, geologically. For while to the geologist as to the Creator a thousand years are but as yesterday when it is past, and as a watch in the night, a million years is nothing to be sniffed at; especially when it is the last million, the one connecting with our own time, and in which the finishing touches were being put in the earth's scenery and its life. Glaciers now cease to be merely an illustration of dynamical geology, of forces now at work on the earth's surface; they open the way to a long and eventful chapter in the earth's history. Great changes have taken place in that time. Some geologists believe that the carving of the Grand Canyon was done within that period. And it was the period during which man was slowly climbing from savagery to his present eminence in a civilization characterized by wholesale murder.

The Flowering of Glacial Geology

Glacial geology, like any growing science, shows increases in content, variety, complexity. The geological texts of today include many matters not dreamed of in the philosophy of Agassiz. To mention but a few, we have: The petrography of the drift; mountain summit and mountain valley sculpture by the snow field and the valley glacier; the long and involved history of the Great Lakes region during the retreat of the last ice sheet; the changes of land level; the sinking under glacial loading when the glacier was present, and the rise after its disappearance; and the bearing of such changes on our understanding of changes within the earth's crust; the working out in detail of the history of the glacial period, possibly a million years in length, and the changes during that time in the land surface, in plant and animal life and in man; the study of the vastly older glacial periods in pre-Cambrian and Permian time; speculations on the cause of glacial periods.

Refinement of Method

No advance in science is more important than that in method, for method is fundamental. Given right method, knowledge comes as matter of course. In the pre-scientific period of the subject, before Agassiz, there were floundering and wild guesses, often based on the Genesis myth, impossible of verification. Agassiz furnished the key which opened the door to genuine scientific advance; but for decades there was slow disentanglement from error, old and new. Science exists in the minds of its workers, who are human beings subject to the common mental infirmities. We have seen what some of these influences were which threw them off the track. They were subject to the general intellectual and scientific atmosphere of their time. They were limited in their outlook by the state of their own science at the time, by its scanty accumulation of fact and by its faulty theory. They were subject, as are all of us, to personal bias of various kinds. They had an inadequate appreciation of scientific method, especially as regards allowing for personal bias. There was throughout the nineteenth century a steady growth in understanding of the scientific method and an increase in the rigor with which it was applied; that is, a steady growth in the scientific conscience. Scientists became more critical of the work both of others and of themselves. In the field of glacial geology, with the increase of workers and the accumulation of field evidence,

old errors were detected and corrected. It should be noted that errors were corrected from within, by the geologists themselves, who had first-hand acquaintance with the facts, not from the outside.

So glacial geology has come limping along through its first century, ridding itself of error, developing its field both intensively and extensively, refining its method; and to-day it presents a very respectable appearance in the geological family.

Three glacial geologists of the highest scientific standing, Gilbert, Chamberlin and Davis, have made definite contributions to scientific method. Gilbert's paper[11] on "The Inculcation of Scientific Method by Example" is of the highest value, as by one who had a clear theoretical understanding of scientific method, and was also one of its best practitioners in America. Method, he says, should be taught, if it can be taught, not by abstract and generalized statement, but by concrete example, both in the classroom and in the field. The example Gilbert himself took was the variations in level of the old Bonneville shore lines about Great Salt Lake. Chamberlin's paper on "Multiple Working Hypotheses"[12] developed in detail a phase of the subject mentioned by Gilbert. William Morris Davis, in numerous articles, gives special attention to methods of study and presentation; develops "a conscious inspection of his own mental processes as a means of improving them"; and, by inference, those of his fellow geologists and geographers, who received his suggestions with varying degrees of enthusiasm. One will find the actual working of the scientific method nowhere better set forth than in the two papers by Gilbert and Chamberlin.

It may seem ungracious to pick on the mistakes of our predecessors and to drag them out for public discussion. But the theory of scientific method is one thing, and its practice is often quite different. And it may be that by the examination of its faulty working, and the errors which follow, we can best avoid errors ourselves. The progress of scientific discovery is more important than the concerns of the individual. The earlier investigators were pioneers, often working under unfavorable conditions, and they have the credit that belongs to pioneers. We honor them as the founders of the science.

[11] G. K. Gilbert, *Am. Jour. Sci.*, 31: pp. 284–299, 1886.

[12] T. C. Chamberlin, *Jour. of Geology*, 5: pp. 837–48, 1897.

GENETICS AND RANGE SHEEP IMPROVEMENT

By JULIUS E. NORDBY

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GENETICS has been one of the active fields of research with small animals for a long time. It has been a very successful field for research, and, because of this success, it was only natural to extend the experience with laboratory animals to our farm animals. In the beginning of farm animal breeding studies, the search for information pertaining to the biological phenomena governing inheritance was oriented around the discoveries of Mendel which activated unprecedented interest in research into the principles of inheritance in both plants and animals. Indeed, animal breeding received such an impetus after the rediscovery of Mendel's laws that some thought was held that it might become, to a very considerable degree, an independent science.

Like so many new developments in science, animal breeding for a while did not seem to have any well-defined and specific interphases. Perhaps here was a new field which might become exclusive and self-sufficient within its own horizon. Astronomy got under way as an independent development—star gazing. It, however, quickly reached its limit as an independent approach to a complex problem. Mathematics was first to come to its rescue. Later, chemistry and physics in their refined developments became very necessary interphases in astronomical science. In the various biological sciences, specialized as they seem to be within themselves, there is no end to the list of interphases. It appears that in no special phase of the very general fields of biology, chemistry, physics, etc., can one hope to make much progress without reference to a vast array of highly specialized and related fields.

As the research worker in animal breeding became more and more familiar with his new field, there appeared in rapid succession new frontiers, new barriers, new interphases. He rapidly became analytical-minded. It was not enough to explain, with some degree of accuracy, why the daughter of a gold medal cow is a star boarder; why many a son of the two-minute trotter is a disappointment, or why all the sons of a league baseball player "do not get to first base." The requirements necessary to explain these problems were but minor stopping-off places in a boundless, unexplored biological vastness. There were more complex barriers that had to be explored. He knew that he could not go around nor over these barriers for an answer to his questions. He must penetrate them.

We find him, therefore, gradually venturing off his own reservation to refresh himself in the special fields of biology, in mathematics, indeed, in biological philosophy. Upon these exploring trips he made discoveries which he would never have made had he not ventured into these fields. But, in his adventures, he acquired the wanderlust. He is off again seeking still newer frontiers.

In the fields of physiology and chemistry he encounters hormones, an endless parade of new ones. Here, he also hears rumors of gene organizers and morphogenetic substances that challenge his spirit of adventure, to say nothing of the stimulating influence it has on his philosophic concept of the complexity of life itself. He knocks at the door of the biochemist. He is thrilled with his researches in endocrinology. In his after-dinner quiet fireside hour he attempts to

explain the interesting matter of mutations. Suddenly he plunges headlong into the field of polarity. Of course, he must also analyze potential differences, which involve the field of force. He is now concerned with molecular physics, because it, no doubt, lies somewhere between the Alpha and Omega of cytogenetics. He may also request the physicist to speak of physiological gradients. And so on in endless procession he discovers unexplored terrain—new frontiers.

As a student of animal breeding he has found now that his approach to the solution of his problems reaches out so far that it goes somewhat beyond the more familiar categories of scientific thought, and he now seeks organization of thought and endeavor in the field of biological philosophy by means of which he hopes to understand and integrate the vast array of problems he encounters in his search for a solution.

Thus, for some time he has been attempting to satisfy his curiosity by adventuring into details that are fundamental to a fuller understanding of the complex problem of inheritance. He has become more and more analytical-minded. And, it is right that he should be analytical-minded. Indeed, he must be analytical-minded! But, he is still a student in animal breeding looking for a solution—looking for a means whereby he can raise the average efficiency in livestock on a fundamentally practical and sound basis. His interest in analytical detail must not, therefore, become a confusing element in his search for a solution—in getting his job done. Because of his detailed contact with the interphases—cytogenetics, physiological genetics, biochemistry, molecular physics, mathematics—he may have, in some cases, developed a temperament which is likely to find more comfort in the problems of analysis than he finds in the problems of synthesis; more comfort in working with an ever-increasing procession of smaller and smaller units, than he finds comfort in trying to synthesize these into a definite organic relationship. He must be familiar with, and have a workable knowledge of, details, but he must likewise be able to visualize beyond details in organic pattern, because, after all, the practical solution lies fully as much in the organization of detail into useful organic life as it lies in resolving organic life into details of structure. The developmental biologist is to-day deeply concerned in discovering principles fundamental to synthesis in development—to organization and integration in animal life.

The chemist meets with fair success when he attempts to explain the funda-

U. S. SHEEP EXPERIMENT STATION AND WESTERN SHEEP BREEDING LABORATORY HEADQUARTERS

DEVOTED EXCLUSIVELY TO RANGE SHEEP IMPROVEMENT UNDER NATURAL CONDITIONS.

SUMMER RANGE FOR RESEARCH FLOCKS

ALTITUDES OF 8,000 FEET ARE REACHED BY JULY. SUMMER GRAZING ABOUNDS ON FLOWERING PLANTS AND BROWSE UNTIL THE FIRST SNOWS BEGIN TO THREATEN SOME TIME IN SEPTEMBER.

mental aspect of how the individual elements get themselves built up into synthetic products. But ask the developmental biologist how the very minute elements of the nucleus get themselves built up into a complex organism! His answer will, in all probability, be less specific than is the answer of the chemist. Much of the biologist's answer, if indeed an attempt is made to make it fairly complete, will be philosophic in its approach.

Ask the animal breeder how successful he has been in making fundamental improvement. His methods have been largely empirical. What hope does this method offer for the future? He himself is asking this question. He is likewise asking, Does any other method offer more hope? And, he is expecting an answer. Science must do its part in supplying this answer. Research has led the way for the competitors of wool, for the competitors of meat. Research must likewise lead the way by not only improving the quality of wool and meat products, but it must lead the way in the efficient production of these products. It will require analysis, it will require synthesis to ably meet the challenge which the trusteeship involved has vested in the animal geneticist.

The improvement of our domestic animals through breeding has always been very largely an art, because its results have been approximate. With an ever-expanding knowledge of biological phenomena, the effort to make it a science has been increasing. It will become a science only to the extent to which we are able to acquire knowledge and control of Mendelian phenomena. Thus it appears that animal breeding offers good possibilities of remaining, in general, somewhat of an art as well as becoming in part a science. This condition must

EWES WITH TWIN LAMBS

LAMBS ARE TRAINED IN SMALL GROUPS TO STAY WITH THEIR MOTHERS BEFORE THEY ARE ASSEMBLED INTO REGULATION BANDS OF ABOUT 1,100 EWES WITH THEIR LAMBS.

not discourage the fullest application of science in our search for a solution.

Analytical genetics and the interphases have paved the way for our excursion into the field of creative genetics. Its task, however, has by no means been completed. It must continue to illuminate the path of progress in animal improvement and pave the way for further adventure. Analytical genetics must penetrate and explore the barriers; creative genetics must make full application of the explorations.

When we speak generally of analytical genetics we have in mind genotypic analysis, particularly with reference to the number or kinds of genes concerned in the inheritance of characters, their interactions and their linkage relations. The analytical geneticist has been able to write the genetic formula for a number of these, and has postulated the formula for many more. In general, those characters for which the gene patterns have been described are comparatively simple, and while they may be relatively unimportant economically they contribute to the fundamental exploring procedure. Many characters, however, that have already been genetically analyzed are fundamentally important. Perhaps the most significant of these are catalogued as undesirable recessives or defects, physiological as well as structural. Progress in quantitative analyses has not been so rapid.

The evidence that is available up to this time seems to indicate that those qualities in animals which have the most significant economic value are complex in their inheritance. The matter of size, as an example, in many kinds of animals is an important utility factor. At least one investigator of size in one of our laboratory animals, the rabbit, has worked for almost 30 years on studies

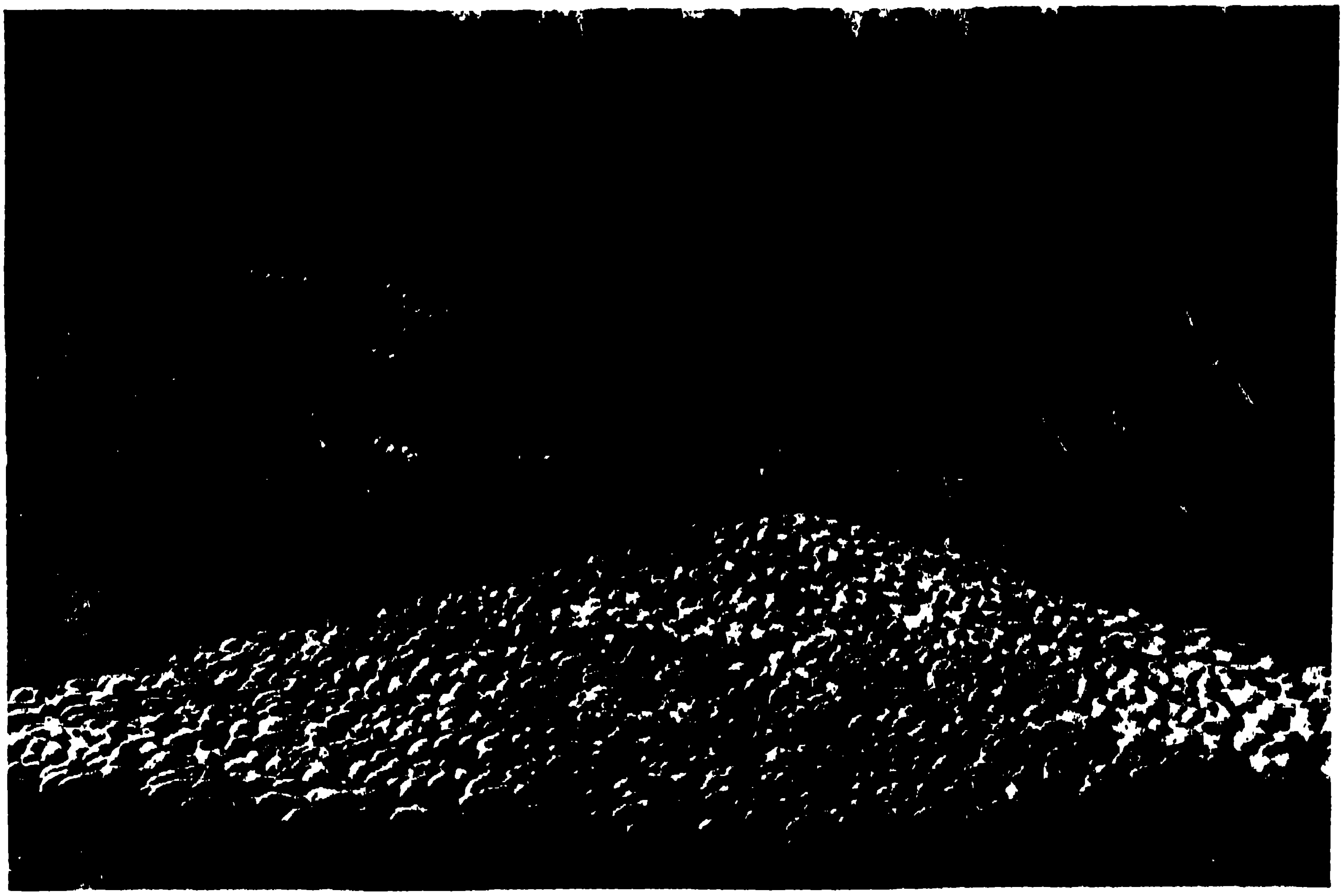
concerned with the inheritance of size. So far he has not identified one gene to which he can attribute a definite effect for size. In another laboratory animal, the mouse, one investigator has established one case of linkage between a size gene and a color gene. But to do this required several years and hundreds of mice. In Drosophila, it has so far been possible to identify only a few of the genes affecting quantitative characters.

The opinion seems fairly unanimous that the utility characters such as size, vigor, physiological performance, etc., are affected by many genes, and that, very likely, some of these are interacting in a very complex manner. Moreover, there is an interaction between genes and environment which obviously contributes to the difficulty of making a satisfactory genetic analysis of complex quantitative characters.

On the basis of this experience it would likely require many, many years and thousands of sheep to complete a genetic analysis of the utility factors in this species. And, if the gene pattern of every character were known, we would still be confronted with the task of combining the desirable genes into sheep that would be an improvement over those we now have, and this task might require fully as much time as the analysis. If as few as ten pairs of genes were involved in a given character, nearly 60,000 genetically different combinations would be possible. To bring order out of chaos in an analytical problem involving such numbers would require the courage of a Daniel, the determination of a Cromwell, the patience of a Job.

In the light of these conditions, when a general improvement program is undertaken, the objective must be very clearly defined. If the objective involves the improvement of sheep for range conditions, then, obviously, all the environmental details of that project must be typical of that sort of environment which generally characterizes the conditions under which the sheep are expected to serve the ranchman. This eliminates any artificial stimulation of growth and development beyond the customary practice of the out-of-door, go-and-get-it sort and the essential winter feeding program. While it would be of interest and some value to determine the ultimate potential development of these breeding sheep when placed under artificial conditions, this development could not serve as a very reliable measure in appraising values of usefulness in the open range country where hardiness, grazing qualities and ability to do well are so vital in seasons and years that vary considerably in food supply and climatic conditions. Obviously, the efficiency of the progeny relative to feed lot gains will be considered in the program. The improvement in the sheep must be the result of "seed" and not of "soil," of breeding and not of an artificial environment, in order that the same degree of success which characterizes their measure of excellence might be reasonably well assured under similar natural conditions. If, however, the environment is permanently improved over that which characterizes the general range conditions, the germ-plasm can accordingly be adjusted to conform with such environmental change. Nature will be an important element in the selection procedure.

There will obviously be an attempt made to analyze the inheritance of some characters in sheep in the Western Sheep Breeding Laboratory, particularly when such analysis will facilitate selection. But this part of the program will be secondary. Undoubtedly in an inbreeding program, which is designed to purify a line for desirable qualities, recessive characters will appear, and in some cases, the inheritance of these can be determined from data that accumulate in the natural course of development of other objectives in the program. If at



CORRAL AND CUTTING CHUTE

SHOWING METHOD OF SORTING LAMBS FOR RESEARCH DATA. THIS STATION IS AT AN ELEVATION OF 8,000 FEET AND CAMP SUPPLIES ARE PACKED ON HORSES. THERE ARE APPROXIMATELY 2,100 EWES AND LAMBS IN THE BAND.

some time in the future it is deemed advisable to attempt a genetic analysis of some of the more complex quantative characters, it would seem that sheep which have been subjected to judicious inbreeding for some time would be more suitable for such an analysis, because they would be more homozygous for the characters involved than they were before any inbreeding was done.

Experimental animal breeding has demonstrated very clearly that there is a marked variation in the genotypic constitution of animals within a breed and that the phenotype is not a satisfactory measure of the genotype. Progeny testing is one means of measuring the genotype, and it is a fairly satisfactory measure when adequate recognition is made of the matings involved. However, all phenotypically desirable progeny may not necessarily be a reliable measure of homozygosity for desirable qualities in the sire or dam of such progeny. Hybrids that are the progeny of parents representing two breeds are very often appreciably superior to their parents, while one parent or the other does not show superior progeny when mated to animals of its own breed. In this case the superiority of the offspring is likely not due to the homozygosity of one parent or the other for most of the good genes of sheep, but rather to the action of complementary genes originating in both of the parents. When breeds have been maintained separately for some time, it is generally conceded that they become somewhat differentiated in their genotypes, though the expression of the respective gene types in the phenotypes within these breeds may be somewhat

the same in outward conformation and in function.

When matings take place between strains or lines within a breed, heterosis operates in a similar manner, but usually to a somewhat lesser degree. Strains within a breed generally do not have the same opportunity to become genetically differentiated as do different breeds, because the influence of popular sires and strains sooner or later is felt in practically all prominent strains within a breed. When there is, however, enough genetic distinctness between strains to produce a material heterosis in their hybrids, this is not necessarily a clearcut measure of the homozygosity of each parent for dominant desirable genes, but rather an indication that there is enough genetic distinctness involved in the mating to effect heterosis. Obviously, one parent may contribute more to heterosis in the mating than the other parent. The relative homozygosity of each parent for dominant desirable genes will govern, to a considerable extent, the contribution from each parent to hybrid vigor in the progeny.

When individuals within a line that is highly inbred, and that are relatively homozygous for desirable genes are mated together, they generally do not produce as vigorous offspring as are produced when individuals from one line are crossed with individuals from another inbred line. Even though the foundation for two lines were equally homozygous for the same good genes at the beginning, they would differ after some generations of inbreeding because different combinations of genes would become fixed in the two lines. When two lines are crossed it is quite probable that heterosis in the progeny would be in proportion to the complementary genes in these lines.

It is probable that the maximum usefulness of inbred lines in commercial production will come from the heterosis obtained from such lines in outcrossing and crossbreeding. If this assumption is correct, then it follows that these inbred lines should be developed to their maximum reliability for this purpose. The ability to repeat desirable performance will likely constitute the major aspect of reliability, and this ability will, in general, be based upon the homozygosity for good genes of the individuals within a line that enter into crossbreeding.

Outcrossing tends to conceal, and not to expose undesirable genes. This type of breeding is most prevalent in commercial production, because it is apparent that the success of a commercial enterprise must not suffer the loss incident to the production of too many common lambs, that might arise at least in the relatively early stages of a close inbreeding program.

Inbreeding, though it is slight, tends to expose and fix undesirable as well as desirable qualities. The more intense the inbreeding in the comparatively heterozygous foundations from which such lines must originate, generally the more severe must be the culling. In some lines this culling may be so severe that it becomes difficult to maintain them. This is an obvious reason why undertakings of this nature should involve large numbers of sheep.

Lines will, probably, vary in the degree of inbreeding which will make them the most serviceable for outcrossing. Likewise, they will vary in their ability to endure inbreeding. For this reason attention must be given to the rate of inbreeding in the lines involved in such a program. Very intense inbreeding within a very heterozygous group would doubtless give rise to a larger number of undesirable segregates than would occur within a relatively homozygous group. Moreover, very intense inbreeding at the outset in a relatively heterozygous group might be the means of failure, and result in the discarding of a potentially suc-

CONTRAST IN WOOL COVERING OF FACE

THE "OPEN FACE" RAM HAS FULL USE OF HIS EYES. THE OTHER RAM IS "WOOL BLIND," A QUALITY WHICH HAS LITTLE IF ANY VALUE. UTILITY QUALITIES FOR RANGE PRODUCTION RECEIVE PRIMARY CONSIDERATION AT THIS LABORATORY.

cessful line in which some good qualities prevail that might be advantageously concentrated by resorting to a less intense program of inbreeding at the beginning, which would allow for more effective selection within the line.

Progeny testing is our best means of measuring the inheritance of sires and dams. Inheritance can not be measured before it has had an opportunity to express itself, hence progeny analysis. If the progeny of successive sons in a line show a successive increase in efficiency for outcrossing it would appear that they are becoming increasingly homozygous for the utility qualities desired. In making suitable progeny tests of successive sons in a line as the inbreeding proceeds, it should be possible to determine with some degree of accuracy how far inbreeding should proceed in the line to produce optimum results for outcrossing purposes.

Inasmuch as no two lines will likely carry the same complementary genes, in kind or number, one would expect a difference in the degree of success that obtained with the various combinations of lines that might be made. It would be unsafe to assume that the potential inheritance of any one line is adequate in itself and that it can not be improved through the introduction of genes from other lines. Therefore, when complementary qualities are discovered through progeny testing in outcrosses, and these are introduced by convergent crossing back to the inbred line, a means may be available for bringing together as many desirable genes as possible in individual lines. This may also prove to be a practical means of not only improving desirable inbred lines, but it may become a means of materially strengthening or, indeed, salvaging for a useful purpose in outcrossing lines that are unable to en-

dure a high degree of inbreeding. Such a system of hybridization could be used between lines and also between a line and relatively unrelated, heterozygous groups, the latter probably offering a bigger opportunity for general improvement in the breed as a whole. The crossing of rams from lines of known performance upon commercial flocks of mixed breeding, or crossbreeding, with controlled heterosis, would seem to be the field in which such rams will extend their influence most widely and most effectively within limited time intervals.

In an effort to develop relatively unrelated lines, the inbreeding program will bring about divergence between the lines, and eventually lines may be evolved that are especially useful for specific purposes. One line may evolve that is especially desirable for long staple; one for excellent mutton conformation; one for freeness from skin wrinkles, and still another for freeness from wool over the face or the "open face" character. When such divergence does arise in inbred lines, then such inbred animals can be used effectually for "corrective breeding," a practice which is much less effective when matings involve heterozygous animals. Moreover, these "specific purpose" inbred lines can be converged back into other inbred lines that are in need of the corrective character involved. Divergence between potential lines is already in evidence in the laboratory flock of Rambouillets for such characters as "open face," long staple, mutton conformation and freeness from skin folds. Inbreeding in the flock was under way about fifteen years ago, although it has become more intense in recent years. The approximate coefficient of inbreeding for the 1940 progeny from 805 ewes involved in 34 potential lines will be somewhat over eight per cent. It will be about 30 per cent. for the most inbred line and about 50 for the most inbred individual.

Creative genetics in sheep is definitely involved if and when progress is realized in bringing together a more homozygous combination of desirable genes. The analytical method gives some hope of accomplishing the desired combinations when characters have relatively simple gene patterns. When complex gene patterns are involved, as in quantitative characters, there may be more hope in a method such as inbreeding that will encourage a drastic reshuffling of the genes with a view of encouraging the production of segregates that are comparatively homozygous for desirable genes. Every new individual has a combination of germ-plasm that did not exist before. This combination, however, may or may not be desirable. Reference is made here to the production of such new gene combinations that are more homozygous for good qualities than those that have existed before—progressive inheritance. Individuals with such gene combinations should be more capable of transmitting desirable gene combinations than individuals relatively less homozygous for these qualities.

The animal breeder is deeply concerned with a desire to express uniformly in animal form and function the result of the best combination of utility genes that it is practically possible to combine. The method of approach in the effort to realize this desire is somewhat immaterial to him so long as the improvement is fundamental and is accomplished at a fairly encouraging rate. A mass attack upon the genotype through inbreeding offers encouragement as to rate of accomplishment, and, obviously, any measurable progress would be fundamental. By means of inbreeding there would be produced desirable as well as undesirable progeny. The percentage of each would be influenced directly by the genotypic constitution of the foundation animals which entered into the production of the lines.

It would be important, therefore, to get as much information as possible about the potential usefulness of a strain before too much effort is spent on inbreeding. Tests of potential inbred lines should be made fairly early in the inbreeding program, and it would seem desirable to make tests somewhat often during the development of the line in order to chart its development rather carefully. It would not seem necessary to test the line in each generation because, if the rate of inbreeding that is used for the line is rather slow, no great change in the homozygosity of the line would be expected to occur in one generation. There might, of course, be large changes in some individuals born within the line due to Mendelian segregation, and it would be hoped that these might become identified by suitable progeny tests. However, it appears important not to confuse the total change in the progressive inheritance within a line, with marked genotypic changes due to Mendelian recombinations in any one individual within the line.

Basically, it would appear that rams in an inbreeding program might be tested for four rather specific purposes, namely, their value for perpetuating their own line; for crossing with other inbred lines; for top crossing with unrelated purebred ewes and for crossing with ranch ewes. This obviously is a difficult assignment, and, in all probability, will be done with comparatively few rams within each line. Perhaps it would not be necessary to make all these tests in every line each generation, because it is probable that there would be a high correlation between the results of certain of these tests. It is difficult to test a ram for his value in perpetuating his own line, because the number of ewes within any one line is not large, and, in general, all ewes are needed each year within the line in order to provide replacements. There will be exceptions to this, but they will be few. Obviously, if the ram proves successful, his female progeny can be added to the line. If he is not successful, then the service of the ewes spared from the line, for the sake of his test, is lost to the line for the duration of his test, and this loss may soon be felt in a reduction of ewe numbers in the line.

CROSS SECTIONS OF WOOL FIBERS
MAGNIFIED ABOUT 250 TIMES. BY MEANS OF THE MICROPROJECTOR THE VARIATION IN DIAMETER OF FIBERS CAN BE STUDIED. A AND B ARE SIDE AND BREECH SAMPLES RESPECTIVELY AND ARE RATHER UNIFORM. SAMPLES C AND D, SIDE AND BREECH SAMPLES OF ANOTHER SHEEP, ARE NOT UNIFORM. THE VARIATION IN D IS NOT ACCEPTABLE.

While the performance of a ram when mated to unrelated purebred ewes or even ewes of mixed breeding may not be definite measure of his performance when used within his own line, it will, nevertheless, be one means of measuring his transmitting qualities, after due consideration is taken of the heterosis involved in such matings. This part of

the program will require that consideration be given to an attempt at standardizing ewes set aside for ram-testing purposes, such standardization to involve the use of ewes for test purposes of the same general breeding and quality.

The "spade and shovel" work has just begun in creative genetics as applied to the improvement of sheep for practical efficiency in range production. The program offers possibilities in the proportion in which foundation animals that are used in the production of potential inbred lines carry desirable genes for the qualities sought and in the degree to which these can be fixed by selection and inbreeding. This may take the form of a temporary stimulant or of a more permanent benefit. The nature of the program of this laboratory should insure both, and by a rational procedure of the inbreeding program the temporary stimulant would naturally be supplanted by the more permanent one. Desirable rams that are the result of one or two generations of inbreeding may prove stimulating in outcrosses. This effect may prove increasingly permanent as the generations of inbreeding continue, providing, of course, there is a consistent increase in the homozygous condition of good qualities with successive generations of inbreeding.

It should be emphasized that the lines now under way at the Western Sheep Breeding Laboratory are not necessarily permanently closed lines, because we can not assume that the inheritance of these lines is adequate in itself and not subject to improvement by outside genes. These conditions are recognized in the program by introducing rams for test purposes, from time to time, with a view of discovering qualities that may not now obtain in the laboratory flocks. No one line can possibly possess the best of the qualities that are in all lines. Therefore, from time to time, crosses of lines that possess complementary qualities and outcrosses followed by convergent crossing back to the inbred line, will be made with a view of bringing together as many desirable genes as possible in individual lines. These can be fixed by further inbreeding. By means of this method it would seem that new gene combinations could be effected that will serve as a measure of how successfully creative genetics can be applied in sheep improvement.

SOME NATURAL HISTORY DESCRIPTIONS OF JAMAICA

By Dr. KATHERINE V. W. PALMER

ITHACA, N. Y.

THE beauty of the island of Jamaica, British West Indies, so impressed Christopher Columbus on a May day in 1494, as he sailed his caravels into a harbor and dropped anchor on the north shore, that he named the spot, Santa Gloria. The name passed into oblivion as did the original natives of the island, the Arawaks, and later the Spanish civilization, but the loveliness of the landscape has stood the test of time. Scenes in that region, such as the deep blue of the sea, the breakers over the coral reef and the wind sweeping through the leaning coconut palms fringing the shore, leave a mental picture that might be called the Santa Gloria of reminiscence.

Jamaica is one of the Greater Antilles. It lies south of the western end of Cuba and west of Haiti, being next to Cuba and Hispaniola (Haiti and the Dominican Republic) in size. Situated in the geographical center of the West Indian waters, the island was naturally in a key position in the historical development, trade and settlement of the Caribbean area.

After Columbus, Jamaica was occu-

E. L. Palmer

NORTH SHORE OF JAMAICA, NEAR WHERE COLUMBUS LANDED.

pied by the Spanish, who exterminated the natives but introduced the Negro slaves. The Spanish were conquered by the English whose rule has been maintained since.

For over 400 years the island has been visited or possessed by explorers, settlers, buccaneers, pirates, traders, planters, seamen, soldiers, slaves, merchants, naturalists, writers and tourists.

From that motley group whose lives in many cases were dominated by interests which may or may not have been allied to natural history, descriptions from their writings are brought together to show that though exploring, fighting, looting or studying, all have added pertinent points to the description of Jamaican nature study.

When Columbus returned to his patroness, Queen Isabella in Spain, and was asked what the island of Jamaica looked like, he crumpled a piece of paper in his hand and placed it before his inquirers. No more graphic description of the topography of the country has ever been given.

The Blue Mountains with mist-covered peaks from 5,400 to 7,360 feet high forming the mountainous northeastern region; the beautiful, deep interior valleys; the roughly cut, sink-hole (cockpit) country of the central and western limestone plateau; the mountains and swamps of the southern coast and the rivers cascading into the sea on the north are all crowded into an area of 4,450 square miles, 144 miles in length and 49 miles at its greatest width.

In contrast to Columbus's brief dem-

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BOSTON BEACH, JAMAICA.

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A COMMON COUNTRYSIDE SCENE, NORTH SHORE OF JAMAICA.

onstration of the general topography of the island are the paragraphs of enjoyable description which R. T. Hill, the geologist, indulges in when in 1899 he wrote of the reconnaissance work in the "Geology and Physical Geography of Jamaica."

Imagination pictures no more exquisite scenery than that which attends the ascent of Blue Mountain Peak. With increasing altitude panorama after panorama of tropical landscape unfolds in rapid succession. At Gordontown, nine miles north of Kingston, where the interior margin of the Liguanea Plain meets the mountain front, the ascent through the red-colored cliffs of the Hope River Canyon begins, which here, at an altitude of 900 feet, debouches into the gravel plain through a boca. A thousand feet above, the white buildings of Newcastle Barracks look like doves upon a housetop, yet we climb so far above them that they seem like toy houses below. At 2,000 feet the Plain of Liguanea with its cities and villages and the shipping of Kingston Harbor, grow smaller and smaller, and finally appear like a diminutive plaza below us. Sometimes our path clings to the side of steep declivities, with an apparently endless slope above and a bottomless chasm below. Again, it follows a knife edge from which we can see beyond, on both sides of the island, the waters of the Caribbean, so distant and so far below that no horizon can be distinguished where the gray of the sea meets that of the sky. Still higher, the forest-covered summits of the limestone plateau, with its rugged back coast border, appear below as an unbroken meadow.

Each step of the way is marked by wonders of the vegetal kingdom. At the foot is the semi-arid south coast chaparral with exogenous banana plants, cocoanut trees, native cactus, and acacias. Ascending Hope River Canyon the delicate deciduous flora of the island begins, while the cliffs are burdened with ferns—golden, silver and delicate maidenhair—besides numerous little flowers which find foothold in the rocks. From 1,000 to 4,000 feet, plantations of coffee are numerous, finding congenial temperature and moisture. At 4,000 feet the government has found environment for its cinchona farm. Above 6,000 feet, in an atmosphere of perpetual

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ROARING RIVER FALLS, JAMAICA.

humidity, tree ferns set in. In this tropical climate such alpine heights offer no obstacle to human environment, and to an altitude of 4,000 feet the slopes are well populated.

The Spanish sought gold in Jamaica but did not find it as a natural product. However, here were brought the gold and treasures plundered from Spanish territory of the New World. On the south side a long sand spit or sand-connected islands, the Palisadoes, extend out from the mainland like a finger crooked to protect the contents of a hand. Thus is formed a well-protected harbor for the largest city and capital, Kingston. At the tip of the Palisadoes is the remnant of Port Royal, the once flourishing city of buccaneers. To-day ships sail over the sunken city of gold and wickedness. Fishermen cast nets in water less than ten fathoms over the former rendezvous of notorious pirates and privateers.

It has been said that Port Royal of the sixteen hundreds abounded in wealth as well as in debauchery. It was called "The Store House or Treasury of the West Indies." Two or three thousand pieces of eight were wantonly squandered in a night. There Henry Morgan, Francis l'Ollonais, Roche Brasilliano and Bartolomew Portugues were the arch chiefs who came or dwelt but ruled in drunken revelry with a bloody sword. However, some pirates were naturalists, as revealed by the writings of John Esquemeling, pirate, who sailed with Morgan. Not only does he describe in detail the ways of pirates and Jamaican taverns but also of giant tortoises, the trees and fruits of Hispaniola, glow-worms, crickets, scorpions, caymen or crocodiles, birds, and none the least, the manatee or sea cow, which he speaks of as a fish.

After a long, tempestuous history, without warning, Port Royal's reign came to an abrupt and terrible close. Between 11 and 12 o'clock on June 7, 1692, as the council of the city sat in session and the inhabitants were going about as usual, a thunderous noise was heard and tremendous earth shocks occurred which split Port Royal in many places.

A first-hand account of that disaster is given by Sir Hans Sloane, the celebrated English physician, scientist and naturalist, who lived through the event. He said,

> . . . The ground heaved and swelled like a rolling, swelling sea; by which means several houses now standing were shuffled and moved some yards from their places. One whole street is said to be twice as broad now as before the earthquake; and in many places the ground would crackle and open, and shut quick and fast: of which small openings have been seen 200 or 300 at one time, in some whereof many people were swallowed up; some the earth caught by the middle, and squeezed to death; the heads of others only appeared above ground; some were swallowed quite down, and cast up again by great quantities of water; others went down, and were never more seen. These were the smallest openings. Others, that were larger, swallowed up great houses; and of some gapings would issue whole rivers of water, spouted up a great height into the air, which seemed to threaten a deluge to that part of Port-Royal, which the earthquake seemed to favour, accompanied with offensive smells, by means of which openings, and the vapours at that time emitted from the earth into the air, the sky, which before was clear and blue, was in a minute's time become dull and reddish, looking like a red-hot oven.

The above description is only a meager item in Sloane's contributions to the chronicles of the natural history of Jamaica. He was a doctor of physic to the Duke of Albemarle as well as attendant on the once pirate, Governor Sir Henry Morgan. Sloane spent fifteen months on the island. During that time he collected 800 plants, most of which had never been named. Skilled drawings of those plants, life size, may be seen in two large volumes published in 1707 and 1725.

Though Sloane's work represents great effort and accomplishment, he is followed by another physician-naturalist who similarly published, in 1789, a tome

on the natural history of the island. He states,

> Sir Hans Sloane hath not collected above 800 species of plants in all his travels: In Jamaica alone I [Patrick Browne] have examined and described about twelve hundred, besides Fossils, Insects, and other productions: . . .

The flora of Jamaica is represented by a luxuriant growth of thousands of species of wild and cultivated plants from the sea to the mountain tops. The traveler from the temperate zone becomes aware of a long list of unfamiliar names. The sour-sop, sweet-sop, breadfruit, tamarind, nase-berry, papaya, mango, custard apple, cacao, cashew, akee, lignum-vitae, pimento or allspice, star apple, banyan, calabash, yacca, annatta, West Indian ebony, Barbadoes Pride, cherimoya, allamonda are only a few of such a list. The breadfruit deserves special mention because of its introduction to the island in 1793 by Captain Bligh, of the ill-fated *Bounty*. Of all the trees which establish a unique sense of camaraderie, the silk cotton tree or Ceba ranks high. Perhaps this is due to one of its members having been singled out in that country by the special appellation of "Tom Cringle's Tree." For a description of that particular tree seen on the main highway between Kingston and Spanish Town, we go to Michael Scott in that vital, reckless sea story "Tom Cringle's Log":

> . . . a large umbrageous wild cotton-tree, which cast a shadow on the ground—the sun being, as already mentioned, right overhead—of thirty paces in diameter; but still it was but a dwarfish plant of its kind, for I have measured others whose gigantic shadows, at the same hour, were upwards of one hundred and fifty feet in diameter, and their trunks, one in particular that overhangs the Spanish Town road, twenty feet through of *solid* timber; that is, not including the enormous spurs that shoot out like but-

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BLUE MOUNTAIN PEAK, JAMAICA, B. W. T.

tresses, and end in strong twisted roots, that strike deep into the earth, and form stays, as it were, to the tree in all directions.

. . . The branches overhead were alive with a variety of beautiful lizards, and birds of the gayest plumage; amongst others a score of small chattering green paroquets were hopping close to us and playing at bopeep from the lower surfaces of the leaves of the wild pine (a sort of Brobdingnag parasite, that grows like mistletoe, in the clefts of the larger trees), to which they clung, as green and shining as the leaves themselves, and ever and anon popping their little heads and shoulders over to peer at us; while the red-breasted woodpecker kept drumming on every hollow part of the bark, for all the world like old Kelson the carpenter of the *Torch*, tapping along the topsides for the dry rot.

To-day the Negroes believe that tree is inhabited by "duppies" or ghosts.

One line in that unsurpassed Negro story of the Barbadoes and Jamaica, "The Wooing of Jezebel Pettifer," by Haldane McFall, reveals a common bit of natural history and a key-note of local color pertaining to the black population —"Through a break in the cactus hedge a white-robed figure stepped lightly into the yard."

The ubiquitous cactus fence so characteristic of the habitations of the colored people of the West Indies certainly deserves attention. The rows of barrel-cacti securely massed together is a device with which nature competes with barbed-wire entanglements for keeping stray chickens, goats, burros, pigs and humans from wandering beyond their rightful boundaries.

When 95 per cent. of the population of the island is negroid, they naturally become part of the landscape. Their common and constant "Good morning, Mrs."; "Good morning, Bokra, I beg you a tuppence," called from any and every part of the bush or road make a friendly accompaniment to a picturesque setting.

The Negro has added his bit to the observations on natural history, as may be revealed by the numerous examples in his long list of proverbs and sayings.

E. L. Palmer

THE UBIQUITOUS CACTUS FENCE.

Out of a collection of 1,383 proverbs about 578 are on elements of natural history. Some which seem pertinent and pithy are as follows: "Ebery John Crow tink him pickney white";[1] "Lilly bush sometime' grow betta dan big tree";[2] "Alligator lay egg but him no fowl";[3] "When morass ketch fire, land-turtle look fe mangrove tree."[4]

[1] John Crow is a vulture (*Coragyps atratus atratus*) with black plumage. The young vultures are white when hatched but do not remain white. Meaning is: What is one's own is always best.

[2] Small beginnings are not to be disdained.

[3] Never look at a subject from one angle only.

[4] Any port in a storm.

E. L. Palmer

WHISTLING FROG ON ITS EGGS

WHICH ARE LAID ON WET TRASH. THESE PARTICULAR EGGS WERE LAID IN A FLOWER POT.

The fauna of Jamaica consists mainly of innumerable insects, land snails, fish and birds. Mammals and snakes are conspicuous by their scarcity. There is only one indigenous land mammal, with the exception of about 30 bats. The mongoose was introduced to keep the rats down, but became in turn an agent of destruction of small animals. The interesting manatee or sea cow feeds in the estuaries or harbors. About five nonpoisonous snakes are known, but all are rare. Lizards are a familiar sight, as is also the large, introduced toad, *Bufo marinus,* which emits a poisonous secretion when handled. At night, whistling frogs produce a constant chorus. These frogs are remarkable in that they lay eggs away from pools. The tadpole stage is spent in the egg.

The fauna and flora of Jamaica have been described best by Philip Henry Gosse, the English naturalist, who in 1844 devoted almost eighteen months on the island to the study of the natural history. He returned to England with 1,747 specimens of vertebrates, 11,675 specimens of invertebrates, 7,586 plants besides hundreds of seeds. But his contribution to the natural history of Jamaica was not so much the accumulation of such numbers of specimens as it was the writing of his first-hand observations of plant and animal in that classic, "A Naturalist's Sojourn in Jamaica," in which his thesis is clearly stated as "Natural History is far too much a science of dead things; a *necrology* . . . that alone is worthy to be called Natural History, which investigates and records the condition of living things, of things in a state of nature; . . ." Passages from Gosse would not give an adequate idea of the book, for it is a continuous description of plant and animal of land and sea. The book should be given *in toto.* As a sample of his style one may watch him with what he refers to in his "Birds of Jamaica" as the "gem of Jamaican Ornithology," the long-tailed hummingbird:

> While I was up in the Calabash tree, engaged in detaching the bunches of *Oncidium,* the beautiful Long-tailed Hummingbird (*Trochilus polytmus*) came shooting by with its two long velvet-black feathers fluttering like streamers behind it; and began to suck at the blossoms of the tree in which I was. Quite regardless of my presence, consciously secure in its power of wing, the lovely little gem hovered around the trunk, and threaded the branches, now probing here, now there, its cloudy wings on each side vibrating with a noise like that of a spinning-wheel, and its emerald breast for a moment flashing brilliantly in the sun's ray; then apparently black, all the light being absorbed; then, as it slightly turned, becoming a dark olive; then, in an instant blazing forth again with emerald effulgence.

With one's memory still clear with scenes such as the nights filled with many sounds of insects, the bell-like ring of a little frog and the synchronized flashes of hordes of fireflies lighting simultaneously about 22 times every minute as they give an impression of masses of lighted airplanes moving across the Hope River Valley, glimpses of Jamaica have been presented from a varied group of roaming and writing people; explorer-discoverer, geologist, pirate, physician-naturalist, narrator, fiction writer, Negro and naturalist. All have observed something in natural history and woven it into the fabric of the cloth of their descriptions. They would, as well as do we to-day, agree with that notorious adventurer, Captain Jackson, who wrote of Jamaica in 1642,

> Ye Temperature of ye Climent, and Salubritie of ye Ayre, may be very well deserned in ye good complection and long life of ye inhabitants, who here attain to greater age than those in many of ye neighbouring islands. It is likewise watered with pleasant Springs and fresh Rivers, and wanteth noe store of safe convenient Harbors for Ships, both on the South and North sides thereof. For briefe, it affords, or can produce, whatsoever, or most things, affected by man, either for pleasure or profit.

CONSERVATION IN PUEBLO AGRICULTURE

II. PRESENT-DAY FLOOD WATER IRRIGATION

By Dr. GUY R. STEWART

SENIOR SOIL CONSERVATIONIST, SOIL CONSERVATION SERVICE, U. S. DEPARTMENT OF AGRICULTURE

THE life of the modern Hopi and Zuni tribes is full of interest for the student of primitive agricultural methods. These people, since their first contact with whites, have clung to their ancient life with a devotion which has preserved much of their early ceremonial existence. In the same way their system of planting corn and minor crop plants has been far less affected than have the Rio Grande Pueblos with Spanish and American agriculture. Valuable light can therefore be shed upon the relics of early ways of growing the traditional corn, beans and squash of the ancients by examining the agriculture of the Hopi and Zuni cultivators.

The Hopi villages lie at the southern end of the high upland known as Black Mesa. The agriculture of these communities forms an interesting example of the manner in which simple conservation practices have been developed to enable the cultivators to live in the midst of a rigorous environment. The elevation at the villages is approximately 6,000 feet, but the plateau rises to about 8,000 at its northern end. This higher elevation gives an appreciably greater rainfall upon the upper portions of the plateau than the 12.7 inches recorded over a ten-year period at Keams Canyon. This greater upland precipitation provides run-off in the main canyons coming out from the upper mesa emptying between the first, second and third mesas on which the eight villages are located. In addition, there is an important seepage of moisture along the mesa top, producing valuable springs at various points below the upper mesa rim. This seepage also makes it possible to grow fruit trees, particularly peaches, at places along the upper mesa and on the sloping land adjacent to the uplands. The local run-off from the sides of the upper mesas is also caught in many places and supplies bean, squash and melon fields. This supplementary water is absolutely necessary for crop growth in view of summer temperatures from 95 to 98 degrees Fahrenheit, combined with strong, drying winds during the spring and fall periods.

The critical factor in the success of the Hopi corn crop is flood water run-off, which comes down the principal arroyos at irregular intervals after torrential rainfall descends upon the uplands. This flood flow fans out over the alluvial flats which lie to the south of the Hopi villages. During the growing season portions of the corn lands may receive run-off at three or four periods during June, July and August. In order that the flood water may be handled successfully, it is essential that the bed of the arroyo should be only slightly lower than that of the field on which it is to be diverted. The light dams of brush and earth which are thrown across the flood streams by the Hopi irrigators are a great aid in stopping gully cutting by preventing excessive deepening of the channel. If arroyos are unchecked so that cutting starts, a gully of twenty to thirty feet in depth may form in a few years, which lowers the flood water to a point where

—Stewart

BRIGHT ANGEL TRAIL OF THE GRAND CANYON

COTTON SEED HAVE BEEN FOUND IN SMALL RUINS ALONG THE LOWER PART OF THE TRAIL, INDICATING THAT THIS CROP WAS RAISED IN THE WARMER PART OF THE CANYON.

it can not be brought upon the land. Hence, regular use of flood water to spread it out and keep the arroyo beds filled with the sand and silt which the stream readily deposits is one of the important factors in successful flood-water farming.

Since the flood flow can not be controlled beyond diversion from the main stream, parts of fields at times may be washed out or other portions may be covered with a heavy deposition of silt and sand. This is one of the risks inherent in any such system of agriculture. It is minimized to a certain extent among the Hopi by the fact that a family may have a share in the clan lands inherited from mother to daughter, which will be located in more than one part of the flood plain. This arrangement of the land holdings also reduces the chance of crop loss from windstorms or from a heavy concentration of cutworms, which might occur before the family and friends could come out and pick them off.

The preparation of land for planting is relatively simple. It commences in late February and is completed during the spring months. Plowing has never been generally adopted among the Hopi, because of the danger of soil loss from wind erosion, during periods of high wind. In most cases the principal land preparation consists of digging out weeds and brush, either with the traditional wooden planting stick or wooden weed cutter, though some cultivators have adopted steel hoes and spades. Part of the older Hopi, however, still feel that steel or iron tools may dry out the soil and make the planted seed likely to suffer from drouth and, therefore, use nothing but the older wooden tools. Each family group generally prepares its own land, the men doing the major portion of the work, but the women and older children may at times be seen working with them. At the same time that the fields are cleared, brush fences and windbreaks are rebuilt on the lighter

—*Stewart*

TYPICAL FLOOD WATER FIELD ON THE FIRST MESA AT HOPI

soils, and new windbreaks will be put in upon fields which have not been planted during the previous year. Any available type of brush or branches may be used, and the same material will be allowed to stay in the ground even after it is defoliated, so long as the branches give some protection against wind action. In the melon and bean fields the old roots will be removed as part of the land preparation, but in corn land the stumps from the previous crop are ordinarily allowed to remain so that the new plantings will alternate with the old hills of corn. At the same time that the flood water lands are prepared for planting, the men whose families have terrace garden plots adjacent to one of the springs, work up the ground and prepare it for planting to chile peppers, onions and early sweet corn. The water of some of the springs is slightly saline, so that salts may accumulate in the upper soil and there may be a tendency for alkali hardpan to form. On such plots the cultivators will often spade up the soil to a depth of 14 to 18 inches, breaking up the hardpan and incorporating any crop residues left on the surface.

—Stewart

HOPI BRUSH CHECKS RECENTLY PUT IN TO CONTROL SOIL BLOWING

The first planting of early corn is ordinarily put out in the terrace gardens in early May, depending upon the season. In most of the villages an official known as the Sun Watcher observes the point at which the sun rises along the southern horizon, and the Town Crier will then announce that the time has come for planting early corn, watermelons and beans. The main planting of corn is not started until after the Town Crier announces that corn will be planted for the village Chief or Governor. This planting is a spontaneous tribute to their leader for his service in arranging ceremonials and advising in clan and village affairs. The organization of such a village planting party is partly wrapped up in mystical tradition

—*Stewart*

HOPI TERRACE GARDENS, NEAR THE WIPO SPRINGS, FIRST MESA

PHOTOGRAPHED WHEN THE LAND WAS BEING PREPARED FOR PLANTING.

—*Stewart*

HOPI BRUSH CHECKS PUT OUT IN SANDY LAND

DURING THE PREVIOUS YEAR AND NOW LARGELY DEFOLIATED. THESE THIN WINDBREAKS STILL GIVE SOME PROTECTION FROM SOIL DRIFTING.

—Stewart

LARGE EARS OF CORN
GROWN AT ZUNI, IN FLOOD WATER FIELD, ON RELATIVELY SMALL PLANT.

and is partly the result of long agricultural experience.

Upon the day set for planting, as the men start from their homes, the women of their family will observe an old Pueblo custom and dash a dipper or two of water over them, in order that the crop which they are to set out may not lack for rain water.

When the party of volunteer workers is gathered together, the men will first hold a short ceremonial smoke and breathe prayers for rain. Prayer sticks are next offered before a field shrine and a little corn meal is sprinkled in the six major directions—north, east, west, south, above and below. After these observances, the planters will start along one side of the field, spacing their planting about three to five paces distant from each other. The rows are located in between the rows of the preceding year and the hills alternated in distance in each adjacent row, so that no two hills are opposite each other, and all are set in new soil.

The planting technique that has been developed is simple and effective. The planter removes the surface soil with his foot and then digs a trough-like hole from twelve to sixteen inches deep. The damp subsoil which is reached at this depth is next loosened and from ten to twenty seed are dropped in the hole and covered with soil to a depth of eight to ten inches. This deep planting enables the plants to obtain the maximum advantage from the moisture present in the soil and allows them to develop a deep root system which can resist wind or the rush of excessive flood water. By the use of a large number of seed, a leafy clump of stalks is started which gives excellent protection to the central stalks when high winds blow at harvest time. These outer leaves may only be frayed remnants at harvest time, yet through their shelter the central stalks are able to grow and mature one or more large ears of corn which are set at the base of the stalk just at the level of the ground. The excess seed also gives sufficient plants so that a fair stand is likely to remain, even though mice or cutworms get into the field. It is often customary for foot races to be run by the planters at some time during their first day's work in a field. This is believed to be effective in starting the corn to growing rapidly.

After the planting is completed for the village Chief, other planting parties of friends and relatives are organized in each village, as only a few fields are planted at a time. The women of the family whose land is to be planted ordinarily provide a mid-day lunch for the workers and entertain them at a bountiful supper when they return home at

night. A great deal of pleasant social life in the villages is centered around these planting parties, while a similar exchange of labor and entertainment is a part of the work at the fall harvest of the corn crop.

As soon as the corn has sprouted, the soil about a hill is kept loose with a digging stick and weeds are removed with a weeding hoe. Some hills which are found to be badly whipped by the wind will be protected, when small, with circles of protecting stones and later with brush windbreaks. In many cases it can be noted that individual hills of corn are surrounded by low banks of earth to hold rain or flood water.

The Hopi cultivator gives his corn crop considerable attention during the early part of its growth. Weeds are cut with a hoe so as to conserve moisture during the time of its most rapid development. Portions of the field which fail to receive flood water from the first storms are leveled off or roughly trenched to promote a more even flow of water if later rains come.

At Zuni, the corn crop is still raised on fields which receive flood water, even though irrigation has been made available for part of the village lands. The ditch-irrigated fields have been planted to wheat and alfalfa, while lands used for corn since traditional times still grow this crop with some modification of the old procedure which was originally very similar to that used in the Hopi villages.

The Zuni corn fields have always been surrounded with a high ridge of soil around the outer edge of the tract to aid in retaining flood water. Such a bordering ridge might be eighteen inches to two feet high and three feet or more wide at the base. This border was formerly raised by hand, but with the increase in plowing at Zuni, the ridge may now be thrown up with several rounds of a

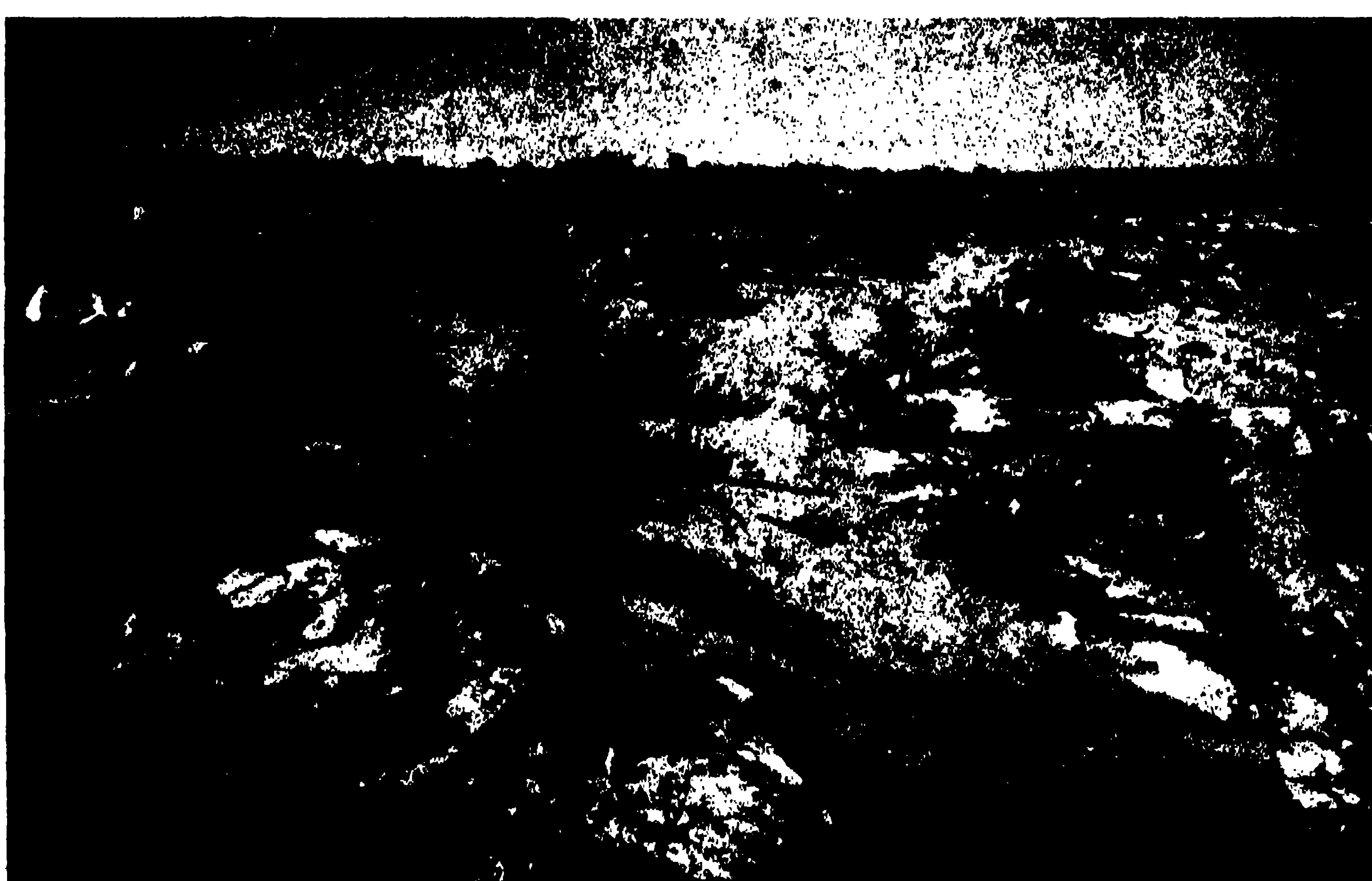
—Stewart

ZUNI CORN FIELD SHOWING THE CUSTOMARY EARTH BORDER
THROWN UP TO RETAIN FLOOD WATER.

—Stewart

"BOSTON GULLY" NEAR ZUNI VILLAGE

FORMERLY THIS WAS A FLOOD WATER STREAM RUNNING THROUGH AN EXCELLENT CORN FIELD, WHEN THE STREAM WAS STABILIZED BY PUEBLO IRRIGATION.



—Stewart

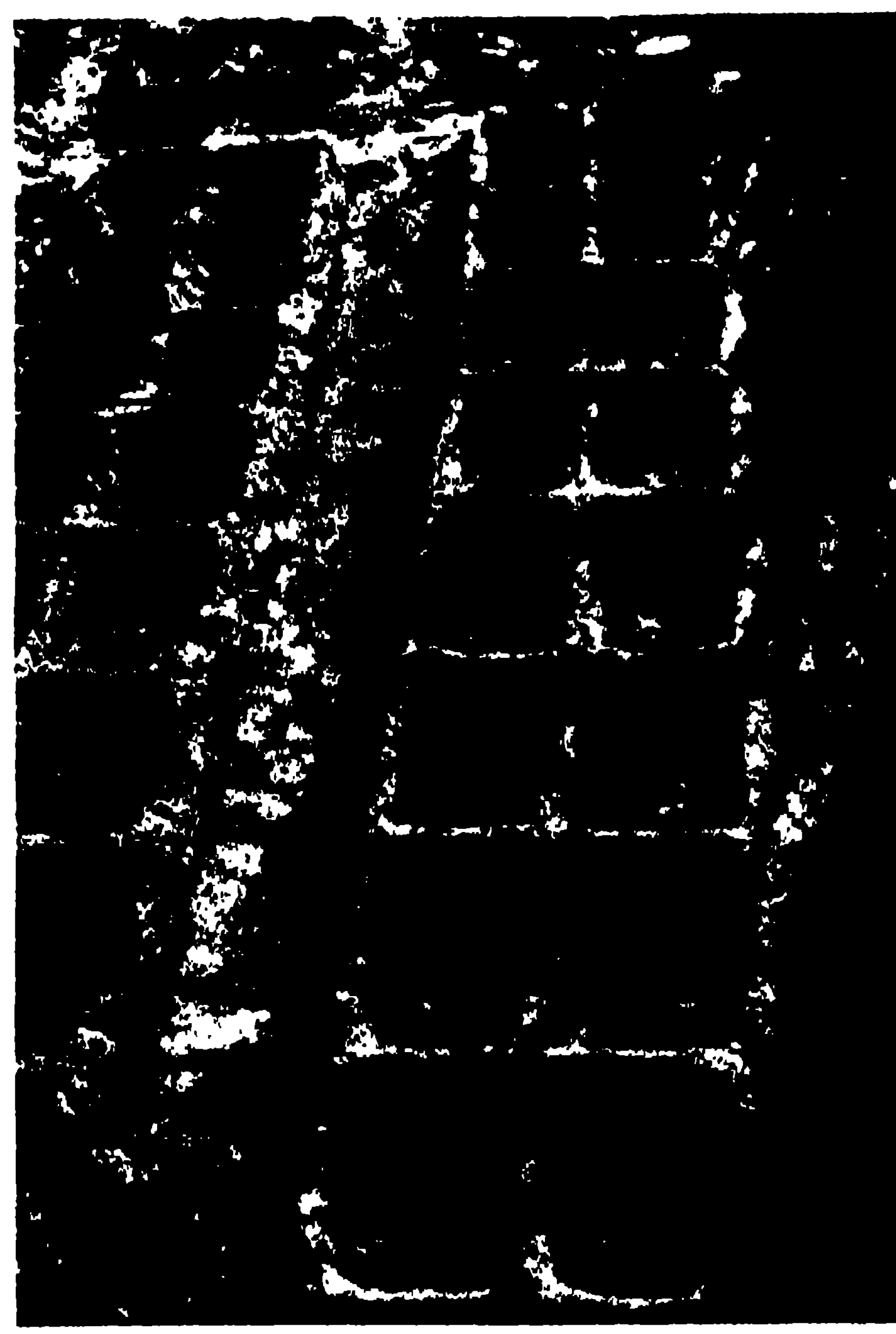
HOPI PEACH ORCHARDS, SECOND MESA, WATERED BY UNDERGROUND SEEPAGE

plow. Many of the Zuni streams furnishing flood water for patches of corn land have a less torrential flow than the arroyos coming out of Black Mesa near the Hopi villages. Consequently, the Zuni cultivator finds it easier to deflect the flood water out of the stream bed with a series of small brush-and-earth dams. At planting time a series of herringbone, radiating earth checks, extending out from the stream bank across the field, will have been thrown up. The brush and earth barriers across the stream itself deflect the water from the channel and spread it fairly even over the entire field with the help of the earth checks. The channel itself is kept up close to the level of the field so that this system of flood-water irrigation constitutes a wonderfully effective method of gully control. The more thoughtful Zuni recognize the value of these methods in preserving the land. On a visit to Zuni during the past summer the Governor of Zuni remarked to the writer: "Zuni farming always keeps the land good." Trouble at times may be experienced from excessively strong flow of water, washing out hills of corn, or too much sand may be deposited onto portions of a field, but spectacular gullying at least is prevented.

Not far from Zuni is a field which was farmed by Zuni cultivators for many years and was pointed out as an excellent corn field. About thirty-five years ago, in the realignment of the reservation boundaries, this field was placed outside the Zuni lands and went out of tribal control. The land was used for pasturage and flood-water irrigation ceased upon the area. Now the former flat stream has cut a deep channel, known as the Boston Gully, which is approximately seventy-five feet wide and twenty to thirty feet deep. It shows clearly that land under flood-water flow must be wisely and continuously used if it is to be preserved.

A series of river gardens are found along the stream banks, both at Zuni and in the outlying villages. These gardens are largely tended by the women and produce crops of chile peppers, onions, beans, early corn and a fair variety of introduced vegetables which have been added to the Zuni diet in recent years.

At both the Hopi villages and at Zuni, the peach crop constitutes a valuable addition to the farming resources. Peaches were acquired at an early date, either directly from the Spaniards or from the mission fathers. In both places early observations of orchardists showed that there were areas adjacent to the mesas where seepage was present in the subsoil from underground run-off. The



—*Stewart*

NEWLY PLANTED PLOT

ZUNI RIVER GARDENS, THE SEED IS PLACED IN A HANDFUL OF MOIST SOIL ON TOP OF THE GROUND.

—Stewart

A RIVER GARDEN AT ZUNI

IN WHICH CHILE, ONIONS, EARLY CORN AND VEGETABLES ARE RAISED BY THE WOMEN.

—Stewart

THE LARGE COMMUNITY VILLAGE OF PUEBLO BONITO, CHACO CAÑON

NEW MEXICO, WHOSE SIZE MAY HAVE CAUSED TROUBLE FROM OVERCROWDING IN PRE-SPANISH DAYS.

peach trees are raised from seed or cuttings and continue to produce for a long period of time. Many of the tops of the trees may pass their period of greatest productivity, but since few of the trees are on budded stock, shoots are allowed to come up from the base of the tree and after a time the new shoots become moderately productive once more. The peach trees are planted by individuals in common village or clan lands and belong to the person who sets out and tends the tree.

—*Stewart*

REMAINS OF AN ANCIENT VILLAGE IN NEW MEXICO

AZTEC, WHICH WAS OCCUPIED DURING SEVERAL EARLY PERIODS, HAD IRRIGATION DITCHES AND WELL-LAID-OUT FIELDS.

Summary

Probably some of the readers of this article will be interested to inquire what the causes were which led to the abandonment of many of the early agricultural communities of the southwest. So far as can be learned there was no one single factor which caused a shift in population and in occupancy of the abandoned villages. Several theories have been advanced for the complete disappearance of the Hokokam communities which formerly occupied the lower Gila and Salt River Valleys. The work of J. F. Breazeale, of the U. S. Department of Agriculture, and associated specialists at the University of Arizona has indicated that a compact, puddled, physical state of the soil may have resulted from the use of slightly saline irrigation water, without plowing or the incorporation of organic matter. This soil condition might finally have caused crop failures where no tool other than a wooden planting stick was used. Other students of this area have suggested a possible rise of the ground-water table, through the excessive use of flood water combined with slow drainage from the valleys. The sudden inroad of warlike enemies, during periods of food shortage in the surrounding country, with the loss of

many communities and the withdrawal of the survivors to the northern Pueblo country, is still another suggestion.

In the case of the northern Pueblos, there is good evidence that the great drouth of 1277 to 1299 caused the abandonment of the Mesa Verde villages. The other settlements at Cañon de Chelly and along the San Juan may have been given up either during periods of crop failure or as the result of wars and raids. In the case of the large communities, such as Aztec and Chaco Cañon, it is quite possible that some overcrowding with lack of sanitation, together with communicable diseases rising to epidemic conditions at times may have acted to depopulate them, combined with wars or crop failures.

There is no definite evidence of any great catastrophic change of climate throughout the region which would have wiped out agricultural plantings over a wide area, though undoubtedly local drouths, such as the serious occurrence at Mesa Verde, may have happened elsewhere.

We may, in fact, be justified in concluding that the system of agriculture based on flood-water irrigation developed through the Southwest was excellently adapted to a maintenance system of farming. The region, however, is one of rigorous extremes, and any one of a variety of unfavorable factors might intervene to throw the primitive cultivator out of balance with the environment from which he wrested a living.

WESTERN MIGRATION AS VIEWED IN 1855

EVER since Paleozoic times, therefore, the Oriental Continent—that is, Europe, Asia and Africa combined—has taken the lead in animal life. Through the Reptilian Age, Europe and Asia had species by thousands, while America was almost untenanted. In the later Mammalian Age, North America was yet in the shade, both in its Mammals and lower tribes; South America in still darker shadows; and Australia even deeper still. The earth's antipodes were like light and darkness in their zoological contrasts. And was there not in all this a prophetic indication, which had long been growing more and more distinct, that the Eastern Continent would be man's chosen birthplace? that the long series of living beings, which had been in slow progression through incalculable ages, would there at last attain its highest exaltation? that the stupendous system of nature would there be opened to its fullest expansion?

Another of our number has shown in eloquent language how the diversified features and productions of the Old World conspired to adapt it for the childhood and development of the race; and that, when beyond his pupilage, having accomplished his rescue from himself and the tyranny of forces around him, and broken the elements into his service, he needed to emerge from the trammels of the schoolhouse in order to enjoy his fullest freedom of thought and action, and social union. Professor Guyot observes further that America, ever free, was the appointed land for this freedom and union—of which its open plains, and oneness of structure, were a fit emblem; and that, although long without signs of progress or hope in its future, this land is to be the centre of hope and light to the world.

In view of all these arrangements, man may well feel exalted. He is the last of the grand series. At his approach, the fierce tribes of the earth drew back, and the race dwindled to one fourth its bulk and ferocity,—the huge Mastodons, Lions, and Hyenas yielding place to other species, better fit to be his attendants, and more in harmony with the new creation.

Partaking of the Divine image, all nature pays him tribute; the universe is his field of study; an eternity his future. Surely it is a high eminence on which he stands.—*From address of James Dwight Dana (1813–1895), delivered as retiring president of the American Association for the Advancement of Science at its annual meeting in Providence, Rhode Island, in August, 1855.*

THE CUCHUMATANES RE-VISITED

By Dr. OLIVER G. RICKETSON, JR.
ARCHEOLOGIST, CARNEGIE INSTITUTION, CAMBRIDGE, MASSACHUSETTS

THE physiography of Guatemala is one of the most complicated in the world, consisting, as it does, of three distinct zones—a low coastal plain, a high central plateau, from five to seven thousand feet above sea level, and eleven major volcanic cones rising another five to seven thousand feet above the central plateau. These volcanic cones, from east to west, are: Pacaya (8,350 feet); Agua (12,110 feet); Acatenango (12,870 feet); Fuego (12,540 feet); San Lucas (11,790 feet); Atitlán (10,000 feet); San Pedro (9,570 feet); Zunil (7,050 feet); Santa María (active: 12,540 feet); Tajamulco (13,600 feet)[1] and Tacana (13,167 feet). These cones all follow along the Pacific margin of the central table-land, and offer a wild jumble of ridges and slopes mostly between 6,500 and 8,000 feet above sea level. Lake beds and canyon floors may lie as deep as 2,500 to 3,000 feet below the surafce of the plateau from which these volcanoes rise.

Although the volcanic peaks follow the line between the Pacific littoral and the central plateau, two main mountain ranges run easterly across Guatemala; they arise from two elevated land-masses in the west—the Sierra Madre southwest of, and the Cuchumatanes directly north of, Huehuetenango. We are here concerned with the latter mountains; they are of great interest to the archeologist, the ethnologist and the zoölogist on account of their inaccessibility and the fact that they present large areas above 10,000 feet with several isolation areas above 11,000. Their tops are composed of great undulating plains lying between rough, hilly country which may be better defined, however, as roughly rolling, when compared to the deeply dissected plateau region or the precipitous slopes of the volcanic cones.

The drainage of the whole mountain region comprised in the departments of Huehuetenango and Quiché is unusual and may be most clearly understood by glancing at the map (Fig. 1). On examination, this shows that the modern town of Santa Cruz Quiché—close to the ancient Quiché Indian town of Utatlán—stands on the narrow watershed between the headwaters of the Rio Grande-Rio Motagua system, which empties into the Caribbean, and the headwaters of the Rio Negro-Rio Salines system,[2] which empties into the Gulf of Mexico via the mighty Usumacinta. On the northerly slopes of the Cuchumatanes, steep, often palisaded, ridges extend northward from the main mass like fingers. These ridges throw the drainage into roughly parallel streams which are eventually absorbed into two river systems: on the northeast by the Rio Lacantun and carried by it to the Usumacinta; on the northwest by the Rio Grande de Chiapas and carried by it to the Rio Grijalva. This latter river and the Usumacinta have many inter-connections on the hot coastal plain of Tabasco, Mexico, before emptying into the Gulf of Mexico.[3] The modern town of Huehuetenango[4] stands on the narrow watershed between the, Rio Negro-Rio Salinas system and the

[1] The highest in Central America; for a full account, see Karl Sapper, "Los Volcanoes de la América Central." Halle, Germany, 1925.

[2] Also called the Rio Chixoy.

[3] P. C. Madeira, Jr., illustrates this coastal plain in Pl. 20 and the Usumacinta delta in Pl. 26. "An aerial expedition to Central America," *Museum Jour.*, Univ. of Pennsylvania, 1931.

[4] Near ancient Saculeu.

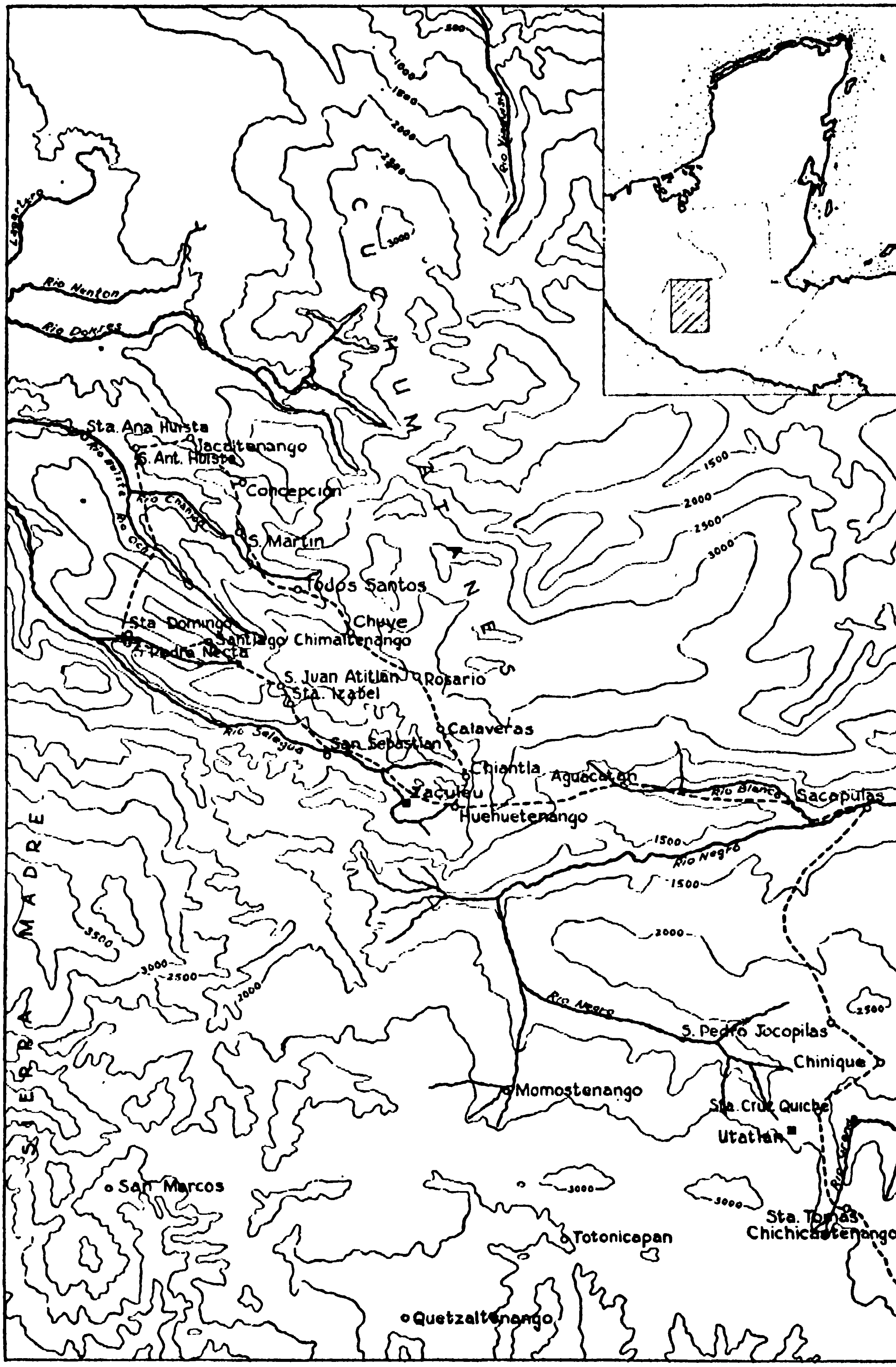


FIG. 1. MAP OF THE CUCHUMATANES MOUNTAINS

SHOWING THE REGION IN THE DEPARTMENTS OF HUEHUETENANGO AND QUICHE, GUATEMALA. TAKEN FROM CLAUDIO URRUTIA, MAP OF GUATEMALA. SCALE = 1: 400,000. ROUTE SHOWN THUS - - - - -

Rio Grande de Chiapas system, just as stands Santa Cruz Quiché on its watershed. Bearing in mind that the topography of this whole area is generally so precipitous that even foot-trails must often follow streams or ridges to make travel possible, the location of two ancient sites of towns on watersheds should not be overlooked by the archeologist; their position would have been strategic from a commercial point of view alone; isolated, as the ruins are, on tongues of land surrounded by deep *barrancas* (ravines), they were also impregnable from the military point of view of a people without fire-arms, as is attested by Bernal Diaz's account of Utatlán: "When he (Alvarado) had made his entry (into Utatlán), he saw what a stronghold it was, for it had two gateways, and one of them had 25 steps . . . and the other entrance was by a causeway."[5] Alvarado barely escaped out of the city over this causeway before it was demolished; informers, as well as his observation of the fact that women and children had been removed from the town, apprised him of the intended fate of the Spaniards had they remained; the city was to have been fired and the Europeans either burned to death or slaughtered as they fled, horseless and afoot, through the one gateway with 25 steps.

From the brief description of the drainage given above, it is at once evident that we are dealing with a special topography not corresponding in any way with that of the continental divide as recognized in the Rocky Mountains of North America or the Andes of South America.

According to Griscom:[6]

Geologically Central America is not a part of North or South America, but is a third element between the two. The folds in the earth's crust which form the Andes and the western ranges of North America are not continued in Central America, where the strata are folded from west to east.

By far the greater part of Central America and Mexico is covered by Cretaceous and Tertiary deposits, both sedimentary and volcanic. But here and there from southern Oaxaca to Northern Honduras, and particularly in Guatemala, Palaeozoic granites and schists, overlaid by limestones containing Carboniferous fossils, are known to occur and below these is a considerable thickness of beds supposed to be Silurian. Wherever the strike has been observed, it is approximately from west to east. Sapper has definitely identified Palaeozoic rocks in the *Altos* (Highlands), of Huehuetenango and Quiché, and the ranges running east in Vera Paz. . . .

The great volcanoes of Mexico and Central America began their eruptions towards the close of the Cretaceous period, and vulcanism was widespread during the Eocene and possibly the Oligocene. Hill believes that the greater mass of the present volcanic heights was piled up before the Pliocene, and the present craters are feeble and expiring phenomena. The extent of the volcanic deposits is very great and most of the southern half of the *Altos* is buried under these to a maximum thickness of 10,000 to 12,000 feet, entirely concealing the original structure of the ground.

In fact, there is evidence that the plains, no matter how dissected by ravines, which surround Huehuetenango, Santa Cruz Quiché, Chimaltenango, Quetzaltenango, Guatemala City and Salamá, to mention only a few places which I have personally seen, are really enormous deposits of ash filling deeper and older valleys acting as catch basins. The ash itself is often white or chrome; locally it is called *talpetate;* it packs tightly, but is easily eroded by running water; these two qualities explain the occurrence of the extremely precipitous side-walls found in almost all the *barrancas;* the *talpetate,* though easily eroded, is nevertheless extremely cohesive; it has little tendency to slide; consequently the *barranca* walls, when not vertical, are pitched at a slope that would not otherwise be possible. The

[5] This narrow neck of land across the ravine is still in place. The quotation is from S. J. Mackie, "Documents and Narratives concerning the discovery and conquest of Latin America," Publication No. 3, Cortés Society, New York. 1924.

[6] L. Griscom, Amer. Museum Natural History, *Bul.*, 64: 24, 1932.

extent of the dissection of these ash catch-basin plains can not be appreciated by a man standing on the plain itself, but it is extremely impressive when seen from a mountain or an aeroplane. The dissection is so great that it offers serious impediments to travel. Piercing this blanket of volcanic deposit, older formations, such as the Cuchumatanes, protrude here and there. It is a short, ten-day visit to these mountains which I shall describe.

Let me state at once that our itinerary was most vaguely outlined. Our plan was to ride from Sacapulas to Huehuetenango and from the latter place as far into the Cuchumatanes as our time permitted. We could find no one in Guatemala City who could give us specific information as to a choice of route or other information. Although this high mountain country is by no means uninhabited, it is seldom visited and then only by native commercial travelers either on foot or horseback, with none of whom could we establish contact before our departure. So far as our party was concerned, therefore, we were visiting country about which we had only the most rudimentary foreknowledge.[7]

We left Guatemala City by automobile on March 31, 1934, for Santo Tomás Chichicastenango, a picturesque Indian village in the department of El Quiché. Here we put up at Alfred Clark's comfortable Mayan Inn, and proceeded the next day, two hours and a half, to the village of Sacapulas, on the banks of the Rio Negro. Here we spent the night at the house of Doña Eugenia Fernández, with whom arrangements had previously been made by Mr. Clark to lodge us and to supply us on the following morning with saddle and pack animals.

Our arrival in Sacapulas caused quite a stir, for foreigners seldom visit it, and, I suspect, the riding trousers of the ladies added to the wonderment of the inhabitants; for a woman in the country districts of Guatemala either follows her husband's horse on foot, or if she rides, modestly uses a side-saddle; she would consider riding-trousers more out of place on a woman than we would skirts on a man. Crowds of little boys soon surrounded our 1931 model car and the Ford truck; from their comments I gathered that both of these antiquated vehicles appeared to them as the last word in high speed development. As compared with an ox-cart, the comparison is valid; and we were already in territory where even the ox-cart is seldom used, owing to the lack of wagon roads, while just across the river all traffic is necessarily by horse or on foot.

We found Sacapulas to be a neat white-washed adobe village, the buildings mostly with tiled roofs, for the valley of the Rio Negro is a distinctly dry, almost desert country. Although its altitude of 4,500 feet[8] above sea-level is only 500 feet less than that of Guatemala City, nevertheless it is hot during the day and cold at night. These conditions are those commonly found in Guatemala in the high interior valleys lying south of a cordillera; their aridity is due to the heavy precipitation falling on the northern slopes of the cordillera, where the hot, moist trade-winds blowing from the sector between northeast and southeast over the lowlands of the Yucatan Peninsula meet high elevations and are rapidly chilled, precipitating excess moisture. Although the heaviest precipitation falls, as I have said, on the northern slopes, some is also deposited around mountain tops; the result is an arid valley lying at the base of better-watered heights. Consequently, con-

[7] See O. La Farge and D. Byers, "The Year-Bearer's People." Pub. No. 3. Middle Am. Res. Series. Tulane: New Orleans, 1931. F. Blom and O. La Farge, "Tribes and Temples." Tulane Univ., New Orleans, 1926. Interesting collateral reading is offered by T. Gage, "The English American. A new survey of the West Indies, 1648," edited by A. P. Newton, London, 1928.

[8] L. Griscom, *op. cit.*, p. 421.

siderable streams may flow through relative desert. The spots of lush vegetation wherever water is available are in strong contrast to the desert vegetation surrounding them. If these contrasts in one valley are sharp[9] the contrasts between two valleys are even sharper; it may truthfully be said that each valley forms a little world of its own; its rainfall and temperature, and consequently its flora, are mainly dependent upon purely local topography, such as the relative positions and altitudes of surrounding peaks, the elevation of the valley above sea-level, and its degree of protection from the humid winds blowing in over a hot coastal plain.

My diary reads:

Left Chichicastenango at 2: 05 for Sacapulas. The country is extremely mountainous, but the very abrupt *barrancas* (ravines) between Los Encuentros and Chichicastenango are absent. The foothills only of the Cuchumatanes tower wall-like across the northern horizon. From the flat, basin-like plain of Santa Cruz Quiché, the topography has changed to steep mountains with rounded contours covered with sparse spindly pine and twisted oak. Occasional organ cactus at the lower levels. Grass burnt brown (this time of the year is the dry season). The road is excellent though very narrow and winding, with plenty of grades that require shifting to first speed downhill as well as up. Arrived Sacapulas 4: 45 P.M.

[9] An idea of the extent of this contrast is afforded by a comparison between Quiriguá and Zacapa, both on the Motagua River and only 25 miles apart. From *Revista Agricola*, Vol. XIII, No. 2, pp. 123–26, the following is obtained: Quiriguá: elev. 225 feet; annual rainfall, 2083 mm, vegetation, formerly a tropical jungle, now banana plantations. Zacapa: elev. 603 feet; annual rainfall, 731 mm, vegetation, mimosa and cactus; L. Griscom, *op. cit.*, p. 19, gives rough rainfall figures as follows: Caribbean Lowlands and northerly slopes of the mountains in Alta Vera Paz, 180–200 inches; Motagua Valley near Zacapa, 6 inches; Salamá (elevation 3,000 feet), 26.5 inches; Guatemala City (elevation 5,000 feet), 55.0 inches; and Pacific Slope, 80.0 inches. The same author (pp. 19–20) illustrates the extreme localization of conditions governing rainfall by describing the meteorological phenomena over Lake Atitlán.

There is not much to say about Sacapulas itself; perhaps we should mention that Thomas Gage passed through it just prior to 1648, on his journey to Guatemala from Mexico.[10] Gage says:

The town, though it be not in the general very rich, yet there are some Indian merchants who trade about the country and especially to Suchitipequez,[11] where is the chief store of *cacao*, and thereby some of this town of Sacapula have enriched themselves; the rest of the people trade in pots and pans, which they make of an earth there fit for the purpose. But the principal merchandise of this place is salt, which they gather in the morning from the ground that lieth near the river. The air is hot, by reason that the town standeth low and compassed with high hills on every side. Besides many good fruits which are here, there are dates as good as those that come from Barbary.

Five days later, after Gage had "wearied out the weariness which I brought in my bones from the Cuchumatanes"[12] he continued on his journey to Guatemala City.

Doña Eugenia allotted us two rooms with rough tile floors upon which to spread our bedding, and after we had arranged our dunnage, I interviewed the mule man. He informed me that a saddle horse could make Huehuetenango in one day, but that with pack animals it would be preferable to sleep at Aguacatan, only six hours distant, slow riding. After various other arrangements had been concluded, I set the breakfast hour for four next morning and we all turned in.

The next morning (April 2) all hands were roused shortly before four, breakfast was eaten, and to my astonishment, horses and mules were saddled and ready. After the usual delays incident to packing on the first morning, we got

[10] T. Gage, "The English-America. A New Survey of the West Indies, 1648," p. 177, 1928 ed.

[11] The present name of a department on the Pacific coast of Guatemala southwest of Lake Atitlán.

[12] T. Gage, *op. cit.*, p. 177.

off from Sacapulas at 7:15, crossed the Rio Negro on a substantial modern bridge, and turned westward towards Aguacatan, following the Rio Negro for a short distance only before crossing a ridge into the valley of the Rio Blanco. We crossed the Rio Blanco also by bridge at a small collection of *ranchos*, and immediately started a long and extremely steep ascent—the Cuesta del Aguila. This ascent consumed more than an hour, as the animals had to be breathed at short intervals, and packs had to be adjusted several times. When we arrived at the top, an open, grassy meadow among pine and oak, a warm sun and a cool breeze invited us for a rest and lunch. As we had already been six hours on the road, traveling about two and a half to three miles an hour (except on the Cuesta), I supposed we must be at least near Aguacatán.

After a forty-five-minute stop we continued, following along the top of a high and very steep-sided ridge from which we could see the Rio Negro on the south and the Rio Blanco on the north. The scenery was magnificent and the road suitable for wagons or automobiles, had they been able to get on it; unfortunately there was no connection at either end; the Cuesta del Aguila had offered difficulties even to the pack mules.

The ridge we followed mounted higher and higher to roughly 5,500 feet; it led us to a flat-topped table-land, with occasional groves of pine and oak, but mostly open grass land. It was but a sparesly occupied region, however; a few flocks of sheep were met with, fewer cattle and still fewer horses. The sheep were always herded, often by small children, occasionally by a woman. On a particularly smooth and grassy plain called the Llano del Coyote we noted six small artificial mounds crowning six widely separated rounded hills. A few houses on this plain, grouped near seepages of water, suggested that the lack of *ranchos* elsewhere might be due to a scarcity of springs. The few houses we passed were all rectangular, with tiled roof and adobe walls plastered white, built on platforms of earth (often with retaining walls of rock) and having a front porch supported by four wooden joists.

Almost all of the houses were accompanied by crude corrals, and had near them elevated, wooden platforms roofed over with thatch; the latter were 8–12 feet high and our guide informed us that they were used as a storage place for corn on the cob in order to protect it from rodents (probably field-mice or ground-squirrels).

It was now approaching three o'clock and our party had had enough for the first day out; our guide assured us, as he had been doing all along, that Aguacatán was "muy cerca." Nothing more definite could we get out of him; since arriving on top of the table-land, the terrain sloped gradually down to the northwesterly; in the blue distance rose the steep slopes of the Cuchumatanes. Somewhere between us and them lay the valley of the Rio Blanco, and in it, Aguacatán; but the valley was not visible. At the present gradient, we would have to ride miles and miles to get to the bottom; this was most annoying to contemplate as we jogged monotonously along at a slow trot, but I encouraged myself by saying that at any moment we would probably come to a sheer drop and see Aguacatán[13] lying directly beneath us.

Although the drop into the valley was not a sheer one, yet it was very precipitous, and deeply dissected with ravines. The pack-train slid and slithered down the slope in great clouds of white dust, plumped into a shallow river-bed full of boulders, called the Rio Seco, and crossed a broad flood-plain to Aguacatán. In response to my enquiries at

13 Elevation, according to Urrutia's map, 1924, 1,500 m.

the only inn, a boy was despatched for the owner, Señor don Gonzalo Ríos, to whom I had a letter of introduction. Upon his arrival, he offered us the use of his unoccupied house just outside the town for the night, an offer we were glad to accept; so we rode through town and came out on to an irrigated and cultivated plain on the north side. It was a refreshing change from the glare through which we had been riding, and the little house. surrounded by irrigation ditches and gardens, was in a real oasis. Less than a hundred yards away a great spring gushed from the foot of a hill; it was the source of the Rio San Juan, which is a stream flowing into the Rio Blanco. The spring measured more than twelve feet in diameter, and the icy water poured from it with a roar.

It was 3:15 when we entered Aguacatán; by the time we had unpacked the mules at Señor Ríos' house, it was all of an hour later. So after a hearty meal and a wash, we turned in at sundown. In these latitudes night falls quickly, with but a short twilight interval between day and dark. By seven o'clock every one was asleep.

The next morning we awoke refreshed, and having very definite information from Señor Ríos, an intelligent man, that a pack-train could reach Huehuetenango in less than five hours, we ate a leisurely breakfast and then rode out to the ruins of Chalchitan, or Pueblo Nuevo. These are a collection of mounds arranged in the typical Maya formation—temple-pyramids grouped around plazas—lying on the valley floor about a mile east of town.[14] Very little stonework was visible; whatever may have existed probably had been used in building the modern town.[15] There are other ruins, not on the valley but on a height, called to-day Pueblo Viejo; according to Recinos, Xolchun. The same author also mentions other ruins called Chichun which he suggests served as a defense-works for Chalchitan.[16, 17] We did not visit either of these sites. The ruins are said to belong to the Mam division;[18] the language spoken in the modern town is a special dialect known as Aguacateca.

We returned to town, met our pack animals in front of the *alcaldia;* in the plaza on which it faces is a large stone trough, hollowed out of one piece of stone, said to come from Chalchitan.[19]

We bade good-bye to Señor Ríos with many thanks for his hospitality and proceeded over a much better road than yesterday's to Huehuetenango, traversing less arid country covered chiefly with scrubby oak and pine, with fewer steep slopes and consequently fewer extensive views. The journey took four hours and three quarters, and we rode into town on anything but jaded beasts; in fact, we were relieved at not meeting automobiles, for our Sacapulas animals were by no means used to them, and we were glad to see the street doors of the Hotel Galvez thrown wide when they heard the clatter of our animals on the cobbled street. We rode, with a tremendous ringing of iron shoes on stone, right through the front door of the hotel across the patio, and into the second court-yard. It is a more dramatic way

[14] Mapped by K. Sapper, "Das Nordliche Mittel-Amerika nebst einem Ausflug nach dem Hochland von Anahuac," 1897; mentioned in F. S. Cruz, *Proceedings*, Pan-American Science Cong., Vol. 1, Sec. 1, Anthrop., pp. 220–24, 1917; A. and C. Villacorta, "Arqueología Guatemalteca," Guatemala, 1927; Recinos, "Monografia del departamento de Huehuetenango," pp. 166, 245 *et seq.*, 1913.

[15] True of the ruins of Tayasal in the Department of the Petén (the church of the modern, nearby town of Flores has a carved stela built into the north wall); also true of the ruins of Utatlán, near modern Santa Cruz Quiché.

[16] A. Recinos, "Monografia del departamento de Huehuetenango," p. 248, 1913.

[17] Karl Sapper, *op. cit.*, 1925.

[18] A. and C. Villacorta, "Arqueología Guatemalteca," p. 145, Guatemala, 1927.

[19] Illustrated in Recinos, *op. cit.*, p. 249. It measures 1.12 meters high and 1 meter wide. (Length not given, but less than 2 meters.)

of entering a hotel than merely handing your bag to a liveried bell-hop.

Huehuetenango is the capital of the department of the same name; it lies at the very foot of the Cuchumatanes at an elevation of 6,800 feet.[20] Any one less hardy than the descendants of the Spanish Conquistadores would build fireplaces in the houses, for the nights are cold. As it is, the only way to keep warm before retiring is to drink a fiery liquid called *comiteco;* this is a superior brand of sugar rum made in Comitán, Mexico, and is affectionately referred to as *alambique al alambre espigado*—distilled barbed wire.

The proprietor of the hotel, Señor Rodolfo Apel, had already arranged for animals to replace those from Sacapulas; so that beyond a few errands there was little to do. I called at the *Jefatura Política* to present my credentials to the governor, Señor Velázquez, and to receive from him a letter to the departmental authorities, both civil and military, ordering them to lend our party all assistance. Travel in this region should not be undertaken without official identifying documents obtained locally.

On April 5, therefore, we rose at five, breakfasted, and after loading and despatching the mules, took a car to the neighboring town of Chiantla.

This town lies about a league from the capital and at the very base of the Cuchumatanes. It is chiefly famous today for two annual fairs, at which there is a very large market for livestock, and a church housing the miraculous image of the Virgin of Candelaria. Gage mentions this image as follows: "I had been informed of a strange picture of Our Lady which was amongst these mountains in a little town of Indians called Chiantla . . . belonging unto Mercenarian friars, who doubtless would not be able to subsist in so poor a place had they not invented that loadstone of their picture of Mary, and cried it up for miraculous."[21] Recinos gives the population of Chiantla as 2,000, and that of the whole municipio as 10,000.[22]

Here our pack-animals joined us—we had planned to see the miracuolus Virgin, but were unable to do so at this early hour—and after minor adjustments to packs and saddles, we started up the famed Ventoso Pass (cerca 11,000 feet) on the old road between Guatemala and Mexico. The ascent from Chiantla is roughly 5,000 feet, which we made in four and a half hours to the summit. For the most part the trail was excellent, though there were steep stretches of loose rock (mostly during the first two hours) and, near the summit, some passages too narrow for mule-trains going in opposite directions to pass. These passages, however, were short, and owing to the winding nature of the trail (which permitted a view of approaching pack-trains, of which there were many), little time was lost. One small village of huts, Las Cordilleras, was passed between Chiantla and the summit; it exists as a resting-place for muleteers. The vista was most impressive. Against the sky could be seen the whole line of volcanoes which stretch along the Pacific border of the tableland from the Mexican boundary south to the Volcan de Agua, towering above Antigua, Guatemala.

Near the summit of the pass was a cross; beyond this the notch through the mountains narrowed. It was a bleak and windy spot, with a few gnarled trees; beyond this gateway the landscape opened onto rolling, grassy and treeless plains, interrupted here and there with gently rounded, sparsely forested hills. These grassy plains would

[20] L. Griscom, *op. cit.*, p. 418.

[21] T. Gage, *op. cit.*, pp. 174–5; see also O. La Farge and D. Byers, "The Year-Bearer's People." Pub. No. 3, Middle Am. Res. Series. Tulane: New Orleans, 1931.

[22] A. Recinos, *op. cit.*, p. 171.

have seemed to afford excellent pasturage, but we met with few sheep and still fewer cattle. I can only suggest the lack of utilization of this land for grazing purposes as due to a combination of three factors: a prolonged annual dry season, a sparse population and no adequate communication with an outside market. The very occasional, windowless, mud-and-log huts scattered here and there only emphasized the primeval silence of these wind-swept mountain tops.

We stopped for lunch beyond the pass near an unoccupied hut, under whose lee we sought shelter from the bite of the wind, by now unpleasantly sharp. Masses of black thunder heads piling on us from the northeast, however, warned us that we had better try to reach a lower altitude, so we pushed on. The trail, after crossing open, more or less rolling, plains, soon entered a narrow valley lying between two long ridges stretching apparently endlessly to the north. Here the vegetation was predominantly gnarled cedar, majestic cypress and other evergreen trees, with a silvery-barked, gray-green deciduous tree resembling aspen; moss or lichen covered the ground or hung from the branches. In the metallic light reflected from the approaching storm-clouds our surroundings took on the appearance of stage scenery rather than an actual landscape. At 2 o'clock the storm broke; at first a chilling, drenching rain, but this soon turned to hailstones as large as pigeon-eggs. These were a relief from the rain, but the hail, increasing in intensity, soon beat upon us with such violence that it became painful to expose our hands holding the reins. In an incredibly short time the ground was covered, and our progress was nearly halted because the hailstones balled up under the animal's feet. The danger of a fall was therefore added to our other discomforts, so I dismounted and called back that it would not only be safer and warmer to get off and walk, but that we would also make better time. Fortunately it was only a half hour further to an abrupt drop into a long, narrow valley leading down 2,500 feet to the little Indian town of Todos Santos. Hail had not fallen here, so we re-mounted and rode along beside a turbulent stream, flowing between steep pine-clad slopes. Primitive huts began to appear on either hand, usually perched in little hillside clearings. None of these huts appeared to be occupied and we marvelled why any one would bother to build such very crude constructions, until our head *arriero* volunteered the information that they were only occupied during the planting or harvesting of the potato crop. During the rest of the year the Indians reside in their houses in Todos Santos.

We approached Todos Santos[23] down a winding lane, flanked on either side by high stone walls. The lane, perhaps because of the stone walls, was reminiscent of a country road in New England, but here the resemblance ended, for the steep-sided spur stretching on our right from the main mountain-mass was so sheer that in many places it was palisaded; great talus slopes extended up the face of the cliffs. It was eloquent explanation for the trails in this region running north and south, following the topography. I now understood clearly why all my suggestions that we plan our route so as to make a great circle back to Sacapulas invariably met with an emphatic "That is impossible!" Parallel series of these great spurs extending northward from the main mass of the Cuchumatanes prevent all east-west travel.

Our reception in Todos Santos was a royal one. As the thatched huts clustered closer, the throb of a marimba be-

[23] Elevation, 2,470 meters; population, 5,000. A. Recinos, *op. cit.*, p. 187.

came increasingly audible; children scampered to the safety of their houses to view the foreigners as they passed; men and women peered through doors or sashless windows. When we entered the grassy *plazuela,* the marimba boomed from the porch of the *municipalidad* and it was evident that the more important men of the town had assembled to welcome us. Nothing could have been more picturesque than this mountain-village square, with its thatched houses, cradled in the narrow valley, and the principales lined up in their extraordinary Todos Santos costume—loose homespun cotton trousers, white with broad red bands, worn under a split over-trouser of natural black wool. Their *capishays,* or tunics, were also of natural black wool; the usual head-dress was a hand-made hat of straw, in some cases worn over a red headkerchief; the latter was the only imported article of dress.

Our cavalcade was officially met by don Luis Rivas, secretary of the Municipalidad,[24] who presented us to the *alcaldes* and other principal men. The latter's knowledge of Spanish was just sufficient to give us welcome in a singsong falsetto; nevertheless the welcome was a cordial one, for we were the first visitors in a year and the first Europeans, probably, since La Farge and Byers[25] seven years before.

The school-house, a great cavern of a room adjoining the *municipalidad,* had been freshly strewn with pine needles in honor of our arrival, and thither we were led by the whole reception committee, augmented by a great crowd of the curious. All of the villagers who were not absent at work on some *finca*[26] on the coast, soon gathered in the room to watch us. This made unpacking a bit of a problem and getting out of our damp clothes an impossibility. However, the whole atmosphere was so friendly that it called for a demonstration of appreciation on our part; so I asked don Luis to send out for aguardiente. A half-gallon carafe, price 50 cents, promptly made its appearance, accompanied by two or three small glasses, somewhat chipped around the rim, and looking as though countless fillings had more or less corroded their inner surfaces. At first I deemed it wise to retain possession of the carafe, thus insuring each and every man one drink, and no more. This precaution was unnecessary, for the *alcalde primero* assumed the rôle of master of ceremonies and saw to it that there were no repeaters until all had been served. The remainder was then polished off by ourselves and the *principales.* Aguardiente is a fiery beverage, but even so we were most grateful for our ration after the rain and cold in the pass.

Finally darkness began to fall and the crowd dispersed. By shooing the urchins out of the room, sufficient privacy was vouchsafed us (aided by the dim light in far corners) to slip into dry clothes. Don Luis informed us that supper had been prepared in an adjoining house, and that he would be honored if we would eat with him. The piece de resistance was venison—a doe, shot that day, to judge by the head and hide hanging from a beam just beyond us. We threw the bones to the dogs under the table.

Next morning, after a night on the school-house floor which required not only all our blankets but sweaters as well, we climbed a spur to some ruins about fifteen minutes' walk from the center of the village, and on the same side of the valley. As La Farge and Byers reported a collection of small

[24] A Spanish-speaking secretary is appointed for towns predominantly Indian, where little or no Spanish is spoken. Such men are usually intelligent *ladinos;* among their duties is included that of liaison-officer between the community and the central government.

[25] 1927.

[26] Plantation.

mounds near Todos Santos called Cu Manchón, we supposed this to be the same ruin, calling it thus to some of the Indians who joined us at the ruins a little later. They informed us, however, that Cu Manchón was on the other side of the valley across the river, and that this ruin was Tucumanchú.[27] Only further investigation would reveal which is correct; the plan of the ruin we visited is the same as that of the Cu Manchón ruin shown in the "Year-bearer's People."[28] I climbed to the tops of all the mounds before our Indian friends joined us. Mound A was crowned by a *quemador*—a place where incense is burnt—but I saw no remains of the stucco figure in the round mentioned in the work cited; no doubt it had disintegrated. Fortunately I had made my little reconnaissance before the Indians came up, for one among them volunteered the information that any person climbing to the top of that particular mound would die—a statement I interpreted as an oblique request not to ascend the mound, and one which I felt would be untactful to disregard in their presence. There was also a small altar in the plaza by this mound which showed the ash and charcoal of freshly burnt wood and recently picked offerings of flowers.

We then returned to town, meeting as we did so, a procession carrying a saint. Music was supplied by a *tunkul*,[29] fife and violin. The procession proceeded to the ruins and there we were told prayers would be offered for rain.

After a noon lunch we got off for San Martín Cuchumatán, four and a half hours' journey distant. The trail had now expanded into a fine lane winding down the broadening valley. The great spurs forming either wall of this valley became less and less precipitous, and enclosed between them a vista northward over ever lower and flatter land, until the far horizon showed a dead level skyline blurred with the haze of smoke from *milpa* burnings.[30] We were looking down on the hot jungle in the State of Chiapas, Mexico, geologically forming the base of the Peninsula of Yucatán. Our road ran through a region that was extensively deforested, for even extremely steep slopes had been put under cultivation by an increasingly dense population. As we descended, the temperature rose and the vegetation became more lush.

About four-thirty we drew into the little settlement of San Martín Cuchumatan; Recinos[31] gives its population as 400, counting both Indians and Ladinos, and its elevation as 1860 meters, compared with 2470 meters at Todos Santos. There was nothing particularly attractive about this town except the view; even the church, whose bells bore the date 1784, was almost in ruins; across the grassy common in front of it and hidden in a *cafetal*[32] was a good-sized Maya mound. On a spur about a mile to the north of the *municipalidad* is a group of mounds called Tilajyon and reported in the "Year-Bearer's People."[33] We did not visit the site.

The *alcalde*, Raimundo Herrera, gave us the school-room for our night's lodging. Next morning when we were packing to leave, he drew our attention to some empty tins which we were leaving behind; when we said we did not want them, he immediately asked if he could take them, to use as cups. I mention the incident to indicate how little contact

27 A. Recinos, *op. cit.*, 187, refers to ruins south of Todos Santos under the name Tecum-Manchu (House of Tecum).

28 O. La Farge and D. Byers, *op. cit.*, fig. 74, *a*, *b*, p. 238.

29 Native drum made from a hollowed log.

30 A *milpa* is a clearing in the forest for planting corn; it is burned to destroy the felled timber before planting.

31 A. Recinos, *op. cit.*, p. 185.

32 Coffee plantation.

33 O. La Farge and D. Byers, *op. cit.*, pp. 19, 232–3. Map, 233.

this region has with the industrial world with which we are familiar.

After a much warmer night than we passed at the higher elevation of Todos Santos, we breakfasted at six and set off for Jacaltenango by way of Concepción; we did not visit the latter town, as it is located on a spur off the main road. The journey was only four hours, 35 minutes, all down grade, the road crossing but one divide, from the drainage of the Rio Chanjon to that of the Rio Azul. The country was much more open and rolling, affording magnificent views. The rise in temperature as we approached Jacaltenango (altitude 1,400 meters)[34] was noticeable, as was the complete deforestation of the land. Recinos gives Jacaltenango an estimated population of 4,000. La Farge and Byers describe the inhabitants as "obviously of mixed origin; some of the Indians have light brown hair and blue eyes; the Indian cast of their faces is weakened by European blood. The very strongly mixed type among the men tends to be gangling in build and shifty-looking." Their costume is usually home-made trousers and shirt of European type; the costume of the women, a white cotton blouse, or *huipil,* with embroidery around the neck, worn outside the skirt, is fundamentally Indian. Their skirts, a plaid design on a blue or red background, are made in Quezaltenango; like other Indian skirts, they consist of a single piece of material wrapped tightly about the hips, and held in place either by a woven belt or by the loose corner being tucked under. The clothes of both the men and the women we saw were for the most part ragged.[35]

Jacaltenango itself impresses one as a slovenly, sprawling town without any of the neatness or picturesqueness so often characteristic of an Indian pueblo. Both the pole-walls of the thatched huts and the pole-fences surrounding them were in a state of bad repair. Children were often seen without a stitch to cover them and many in a state no cleaner than the animals living with them; the dogs were scrawny and mangy. The dirt streets through which we rode were full of rocks and uncared for, without any attempt at drainage. One felt that they would have been full of refuse were it not for an efficient scavenger department formed by dogs, pigs and buzzards. At the far end of town we reached the plaza, more like a large common, on which faced the church, the *juzgado municipal,* the school-house and several better-class houses; but there was nothing about it reminiscent of the usual Latin-America plaza, which generally shows at least an attempt at formalization — fountain, band-stand, flowers, benches. Here there was nothing but a big, grassy square without even the indication of streets or sidewalks.

We stopped in front of the *municipalidad,* and I dismounted to present my letters from the *jefe politico.* Before I entered I was careful to have my coat on, my hat off, and to tie my machete to the saddle, for one may not present oneself with arms of any description. The *secretario* greeted me cordially, but while I was talking to him, I felt something tugging at my foot; an *alguazil*[36] was removing my spur. Quite at a loss to know just what this meant—whether it was a custom of courtesy on their part or an infraction of etiquette on mine—I continued the conversation. When the *alguazil* had removed one spur, I presented my other foot; when he had removed both spurs, he picked up his stave of office, crossed the room and deposited the spurs on the *alcalde's* desk; I then realized that there would be a fine for their return. However, it

[34] A. Recinos, *op. cit.*, p. 195.

[35] Perhaps we should add that the world-wide depression has its effect here as elsewhere.

[36] Employé of the municipality, serving by rotation.

did not seem to be an opportune time to make any protest. By virtue of the letter we were assigned, as usual, the school-house, and *alguazils* were despatched to see that our needs were supplied, in the way of firewood for cooking and fodder for the animals. During the process of unpacking, I forgot about the spurs, and after lunch the sudden change to this lower altitude, sent us all to our bedding rolls for a siesta. I was called from this later by an *alguazil's* informing me that the *alcalde* wished to see me. I then remembered the spurs, and prepared myself to pay a small fine with the best grace possible for my unwitting misdemeanor. But I was not prepared for what took place; in the presence of the *alcalde* and another official, the *secretario,* obviously under orders, read me a long lecture on the lack of respect I had shown duly-constituted authority. Although this made my gorge rise, I refrained from comment until a pause in the *secretario's* speech; then I respectfully drew their attention to the fact that I had put on my jacket, removed my hat, and left my machete before entering, and that my failure to remove my spurs was due entirely to my ignorance of such a requirement, and not to any intentional slight on my part. The spurs were then returned to me without fine—"in view of the letter which I bore from the *jefe politico.*" Jacaltenango gave us the only unfriendly reception that we were to receive during our journey; even the forage and firewood was supplied grudgingly, although the price asked, and paid, was more than the regular one.

Next morning we were up before dawn and glad to shake the dust of this inhospitable town from our feet. We had now reached our furthest north, and from here our road led us back by a different route to Huehuetenango; it would take us westerly across spur ranges to San Antonio Huista, and thence across more spurs to San Pedro Necta, on the Rio Nillá, just above its confluence with the Rio Selegua; the latter stream arises in the environs of Huehuetenango. However, the trail did not follow up the Selegua Valley, but out across boldly mountainous country through Santiago Chimaltenango, San Juan Atitlán, Santa Isabel and San Sebastián, approaching Huehuetenango from the northwest.

Upon leaving Jacaltenango the road immediately started the ascent of a steep ridge, dropping just as suddenly from the crest into the neat *pueblo* of San Antonio Huista. Here in a picturesque and anciently cobbled plaza a colorful market was in full swing; our cavalcade turned into it, and of course the pack-mules followed. A sergeant from the *comandancia* immediately presented himself and our guide Eugenio whispered to me: "We cannot let the animals stand here." As we had attracted a good deal of attention, he advised me showing my letter. The others being only too willing to delay in the market, I dismounted and fished out the letter; although the sergeant was more than civil, I had a distinct impression that five foreigners at once had completely paralyzed his mental processes. Unable to cope with what was no situation at all, and unable to read (for a young recruit in his 'teens had been summoned to read haltingly the contents of the letter), he decided that nothing would meet the occasion short of sending for the *comandante militar.* As it was only nine o'clock of a Sunday morning, the *comandante* was no doubt leisurely arising; but sent for he had to be. Ruth Reeves began sketching and was promptly surrounded by a gaping multitude; my wife and Honor Spingarn were lost among the fruits and textiles in the market; a plot back of the *comandancia* was assigned to us to park our

animals, while I sat on the *corredor*[37] of the *comandancia* chatting with the sergeant. I felt that just so long as I made no attempt to leave, the sergeant was reassured of my legitimate right to be alive and at large. The *comandante* then arrived, in trig military uniform, and immediately offered us any assistance of which we stood in need; when we assured him that we were merely "*de paseo*" he stamped our letter and bade us a most cordial God-speed.

Knowing that prolonged delays with a pack-train are fatal, I tried to get every one under way immediately. But Eugenio had gone off to buy bread, and the others were lost in the beauties of the plaza market. So I pushed on ahead, telling everybody to hurry. In half an hour the outfit caught up; we crossed the River Huista on a covered bridge and then followed the sparkling little river upstream; at noon we unloaded and picnicked on its banks, taking a swim in its none-too-warm waters. The vegetation was open forest, mostly oak, with grass beneath; on the higher slopes, pines. After lunch, the trail led first up and then down over a series of razor-back ridges, with extremely steep gradients; about 3:30 P.M. these ridges gave place to very steep, broken mountains; at 4:30 we dropped into a cup-shaped valley. Here we passed a tumble-down *rancho* and I asked the man sitting on the *corredor* if he could sell us fodder for the animals; he had none, nor did he or our guide know how much further it was to Chichim, where we had planned to spend the night. I was tempted to stop, as it was late, but after a consultation, pushed on, chiefly because there was no fodder and not a level ell of ground on which to spread our bed-rolls. The country was so well-watered that I felt sure we could find a good camping place ahead.

But the trail led on to a great ridge with no streams, no single level spot, no grass for the animals, and no houses. We rode along this ridge, marveling at the scenery (and where the ridge was going to lead us), until 5:30, when we came upon two old grass-thatched lean-tos with ashes from cooking fires in front of them; and here I announced that, water or no water, we would spend the night, as darkness would soon be falling. Examination revealed huts not too far down the side of a valley on our right, so I sent Eugenio to investigate; he reported water and a pasture belonging to a *finca,* but there was no *mayordomo* to give us permission to enter. However, we rode down; the Indian *mozos* would not sell us firewood and one said we could not stay without permission, but by this time the packs were off and we were all scrambling to find the levellest spots on which to spread our bedding-rolls. We gathered some dead wood and threw together a hasty supper; the *mayordomo* then arrived and proved most amiable over a cup of chocolate. He said the *finca* was called Ixnul, and that we were very welcome, but please to stake out the animals lest they get into his foot-high corn. When darkness fell, we found ourselves looking down into a fairy bowl with a myriad fires; this was the season for burning *milpas.*[38] Long ragged lines of fire burned slowly up the slopes, looking like gigantic glow-worms; smoldering stumps dotted the landscape here and there with a dull glow, and occasionally a dead tree, burnt through at the base, would fall with a reverberating crash and a galaxy of sparks. Thirty minutes after dark we were all sound asleep.

The chill at this high altitude aroused us before dawn; we breakfasted at the first light, and started over a much narrower and rockier trail, with even

[37] Porch.

[38] In Guatemala, corn is cultivated by the *milpa* system; land is cleared at the beginning of the dry season, the felled bush allowed to dry until just before the rains, when it is burnt, and the seed planted.

steeper grades than the day before. As we proceeded, more or less to the southerly, each valley became increasingly arid. The mountains, although just as high and steep, exhibited fewer rocky crags; the long, often palisaded, ridges of the Todos Santos region were replaced by a tumbled terrain—hills jumbled every which way rather than in long parallel rows. Before we completed the ascent to the height of the pass the road ran through majestic groves of enormous *ciprés*.[39] Judging by the size of these trees, the mossy forest-floor and the presence of anciently fallen trunks of the same size, I assumed that these now scattered groves were remnants of a primeval forest which had once covered these slopes. If my memory serves me correctly, such groves only occurred on the northerly slopes, presumably because it would be on them that the greatest precipitation fell. The countryside, though large areas had been deforested for *milpas*, was by no means thickly populated.

Once through the pass the road dropped precipitously, through scraggy, second-growth oak for the most part, into the Selegua drainage. For a long time during this descent, we could see the town of San Pedro Necta almost directly beneath us; the final descent to it was by far the narrowest and steepest we had yet encountered, the animals swinging head and neck over precipitous slopes at every zigzag. On the opposite side of the valley was a great half-dome presenting to our view a true precipice at least a thousand feet high. As I noted afterwards from below, the road here followed down one side of a hanging valley that debouched above the valley of the Rio Nillá.[40]

At noon we arrived on the outskirts of San Pedro Necta, clattering over the old Spanish cobbles direct to the *municipalidad,* closed, of course, for the noon hour. Everywhere we saw neatly painted stone-and-plaster houses, with fat and well-cared for dogs asleep in the doorways or barking a friendly welcome. Within a few minutes of unloading our packs the *primer alcalde* arrived, with a courteous "Señor, en que puedo servirle?" In five minutes he had sent for a pint of aguardiente, ordered the school-room swept out, and sent off a boy with instructions to a private house to prepare us luncheon. After the first aguardiente, he sent for the *comandante,* because, as I found out later, the school-room was not good enough for us; we were then given an unoccupied room in the *comandancia,* with a *pila*[41] and a latrine. Our comfort was complete; when we were summoned to lunch, we parted from Colonel Heraclio Rodriguez, the *comandante,* and Señor F. Lizardo Díaz, *secretario municipal,* with assurances of our gratitude and a promise to accompany them to some ruins above the town which the latter had just visited the day before for the first time.

A delicious lunch in four courses was no preparation for a climb to the ruins; we managed to stagger up, however, about four o'clock—a terriffic climb it seemed, although we daily rode our animals for eight hours over similar grades. The ruins consisted of a single plaza on a spur, built up from 5 to 7 feet on the northerly side with a slab-stone retaining wall, to make it level. (Fig. 2.) The highest of the seven mounds comprising the group still stood about six feet; most of them showed stone sidewalls, of flat slabs like the retaining wall, laid up without mortar and unfaced. Sherds occurred in the cornfield planted there. (Plan, Fig. 2.)

The *secretario* told me that the ruin was called Tepam—undoubtedly a corruption of the Nahuatl *Tecpan*—and volunteered the following history: its original name was Tecpan Usumacinta

39 Our guide called these trees *ciprés*, cypress.

40 A confluent of the Selegua.

41 Water tank.

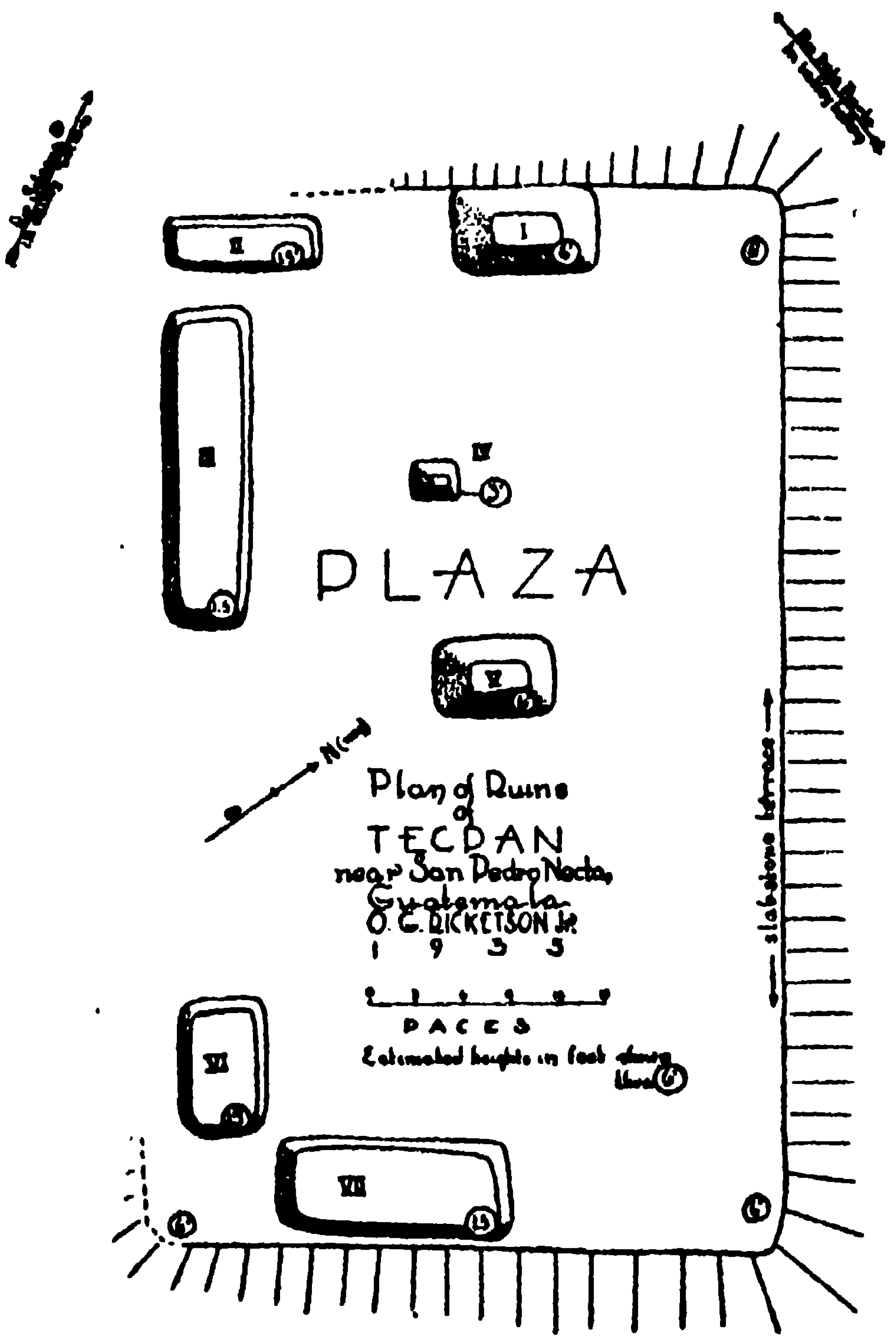


FIG. 2

and its original site was further downstream; the inhabitants belonged to the Mam division of the Maya stock, and had been driven back to this location by an Aztec invasion; the invaders settled on another spur across the river. When the modern town was settled, the half lying on this side of the river was called San Pedro Necta and was Mam; that on the other side was called Santo Domingo Usumacinta and was Aztec. Finally the two settlements united in building one church and to-day it is one town. Such a history should be susceptible of archeological proof.

After examining the ruins we literally slid back to town; the *comandante* graciously showed us some excellent decorative panels done by his son in oil, and at the invitation of the three town officials we repaired to a tiny cantina for aguardiente and lemon juice. The drinks were served by a fine-looking woman; one knew instinctively that the glasses would not only be clean, but polished.

Next morning, April 10th, we willingly paid the two dollars and fifty cents asked for three delicious meals for five people and regretfully left this friendly town for our last night before returning to Huehuetenango. The road here was an excellent one, suitable for wagons were it not for occasional ascents and descents and fords not passable to wheeled vehicles; the country itself, though mountainous, was less rough than that over which we had come, the hills more rounded. It was also more arid, and, although the altitude varied between 4,500 to 5,500 feet, it was much hotter; perhaps the increase in heat was the more noted on account of our descent from higher altitudes, as well as the lack of shade, for the territory is practically deforested. It is densely populated and everywhere cultivated. I noted that many Indian *ranchitos* had a grove of pines planted near them, in a circular formation. Although the planting of pines is in itself easily explained on economic grounds, I know no explanation for planting them in circles.

Our road led us through Santiago Chimaltenango, an unkempt mountain village perched on a spur at an elevation of 2,800 meters,[42] and then San Juan Atitan.[43] Agriculture, some lumbering, (of course without benefit of sawmills, all planks being sawed by hand) and sheep-raising seemed to be the occupations of these remote villages. Since there was nothing of interest to detain us, we continued to Santa Isabel, the smallest *municipio* in the department.[44]

[42] A. Recinos, *op. cit.*, p. 179. Population, 1,500 (Indians).

[43] *Ibid.*, p. 177. Recinos gives "Atitan"; Urrutia's map, "Atitlan." My diary "Atitan." Population, 2,500.

[44] *Ibid.*, p. 177, 12 sq. kilometers. Temperature varies from 10–18 degrees Cent., depending on elevation.

Its small grassy square was surrounded on three sides by very dilapidated stone-and-mortar buildings, thatch-roofed; one of these was all that remained of a small church, still in use, however; another was a long building containing several rooms, used as the *municipalidad* and the school. The third side was open to a view of the valley. The *secretario,* a ladino, could speak Spanish; upon presentation of my letter, he translated it into Mam (I suppose) to the *alcalde,* a dour-looking Indian dressed, as were the other *mayores,* in a natural black wool *capishay* and red head-dress. We were assigned to the school-room, and a fee—eight cents—demanded for its rental.[45] An *alguacil* was despatched to sweep it out; this he did with a leafy branch; seven more men were despatched to bring in as many bundles of cornstalks for our animals, at eight cents the bundle. As I was running low in change, I tried to pay them with two quarters and six pennies, but this they refused to accept as there was no change in the village; so I borrowed enough pennies from the rest of our party to make seven piles of exactly eight cents each. We cooked our dinner over three cents' worth of wood, and sent heaping plates to the *secretario* and the *alcalde;* they had courteously declined our invitation to eat with us. After supper the cold drove us to our bedding rolls early; in fact, it got us chattering out of bed before dawn to make hot coffee and get under way by sun-up.

This was the last day of our trip; the trail led through San Sabastian, whose ancient Mam name Recinos tells us was Toy-hoz[46]—"among the aguacates," a town re-founded on its present site in 1891 following a destructive flood of the Selegua. Although it is located on an automobile road, down bridges prevented our cars from meeting us here. We had telegraphed for them to meet us further along the road, at a place called Chancol. Nothing affords more uninteresting riding than a highway suitable for automobiles; this one, stretching endlessly under a blazing sun, was no exception. It followed the valley of the Selegua through dry, dusty country burnt brown by the drouth of the "dry season." A small Maya plaza surrounded by mounds, between two and one half and three miles out of Chancol, was the only object of interest that we passed.

We reached Chancol at 11:30, but no cars awaited us. So we continued. At 12:10 the mid-day heat was scorching. Some caustic remarks had just been made about the sacredness of appointments in Central America when we heard an automobile horn and were nearly run down by one of our cars; the cars had been held up by repairs to the road where it passed through a defile. We piled off the animals, flung our saddle-bags in the car, and sped on our way (at 15 miles per hour) leaving the truck to await the pack-mules. We had been nine[47] days on horseback and had covered approximately 100 miles (as the crow flies) through a most picturesque and seldom-visited mountain region.

[45] Total expenditures since leaving Sacapulas, not counting mule hire, for our party up to this point had been less than $15.00. This was carried in denominations of not over 25 cents.

[46] A. Recinos, *op. cit.,* p. 176.

[47] April 2nd to 11th, 1934, inclusive. (One day spent in Huehuetenango.)

BASIC PRINCIPLES OF THE NEW MECHANICS

By Dr. G. GAMOW

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THE proposition that *any moving material particle occupies in any given moment of time a definite position in space, and that these positions form a continuous line known as trajectory* was always considered as self-evident, and formed the fundamental basis for the mechanical description of the motion of material bodies. The distance between two locations of a given object at different times, divided by the corresponding time-interval, was leading to the definition of its *velocity*, and on these two notions of location and velocity, all classical mechanics was built. It probably never even occurred to any physicist or philosopher that these most fundamental notions used in the description of the outside world can be to any extent incorrect, and it was customary to consider them as given "a priori" (whatever this expression might mean).

However, the application of classical mechanics based on this simple kinematic notion, to the study of the motion of the minute particles, such as electrons, taking place within the miniature atomic systems, was gradually leading to the conclusion that something must be wrong with this old and renowned system. It was also becoming clear that the failure of classical mechanics to describe properly the processes of intra-atomic motion could not be avoided by some simple changes of its basic equations and that it was actually its fundamental principles which were failing within the atoms. The simple kinematic notions of location, velocity and trajectory of motion, constructed by us on the basis of everyday observations, turned out to be *too rough* when applied to the extremely small particles which we have to handle in atomic physics. But if these general notions are no good at all for the intra-atomic world, they also could not be absolutely correct in the case of motion of larger bodies. Thus we are being led to the conclusion that *the principles underlying the classical mechanics must be considered only as some very good approximations to the "real thing,"* approximations which badly fail as soon as we turn to the systems more delicate than those for which they were originally intended.

THE IDEA OF MINIMAL ACTION IN MODERN PHYSICS

The essentially new element which was brought into physics by the study of atomic phenomena consists in *the existence of a certain minimum for all possible interactions between different physical systems.* It was first indicated by Max Planck in 1900 that no consistent theory of radiation is possible unless we accept that the radiative energy is emitted by material bodies only in a form of certain portions or quanta of energy. The amount of energy contained in each of these radiative-quanta (or the light-quanta) is proportional to the emission-frequency and can be written in the form:

$$E_{\text{radiation}} = h\nu = \frac{hc}{\lambda} \tag{1}$$

where h is the famous constant of Planck ($= 6{,}547 \times 10^{-27}$ erg. sec.), ν is the frequency and λ the wave-length.

It was later shown by Albert Einstein that the phenomenon of photo effect, in which the kinetic energy of emitted photo-electrons depends only on the frequency but not on the intensity of the il-

lumination, gives an excellent proof of the validity of Planck's hypothesis extended to the radiation as it propagates freely through the space. In fact, the classical physics would lead us to the conclusion that the less intensive light must also give less energy to the electrons knocked out from material bodies. But, if the radiative energy is always concentrated in certain elementary portions, depending only on the frequency, the decrease of the intensity of light will cause only the decrease of the total number of photo-electrons, but not of the energy of each one of them.

Still later the experiments of Arthur H. Compton have also shown that, in its interaction with the free electrons, the light behaves as if it was formed of a number of separate energy-packages amounting to $h\nu$ erg each.

Parallel with this progress of the quantum point of view in the problems of radiation, there was developing a very analogous situation in the case of purely mechanical systems. It was first indicated by Niels Bohr in 1913 that the stability of electronic motion within an atom and the discreteness of atomic spectra could be understood only on the basis of a hypothesis that *the mechanical energy of atoms could accept only a certain discrete set of numerical values.* This hypothesis was strongly supported by the beautiful experiments of J. Franck and P. Hertz, who have shown that the bombardment with the fast electrons can produce any sensible changes in the bombarded atoms, then and only then when the energy of electrons reaches certain well-defined values. The formula defining the quantum of energy of mechanical systems is more complicated than in the case of radiation, and depends on the particular structure of the system in question. One can say, however, that the order of magnitude of these mechanical energy-portions is very well represented by the expression.

$$E_{\text{mechanical}} \sim \frac{h^2}{ml^2} \tag{2}$$

where m is the mass of the moving particle and l the geometrical dimensions of the system. We see that whereas in the case of radiation the quantum of energy decreases with the increasing wavelength of emitted light (formula 1), the quantum of mechanical energy decreases with the square of the dimensions of the system.

It must be specially stated here that *the both above given expressions for the minimum amount of radiative and mechanical energies do not represent the results of some special theory, but can be considered as derived directly from the experimental evidence of modern atomic physics.* This notion of minimum energy, leading to a certain lower limit for all possible physical interactions, represents something absolutely new and unknown to classical physics. Therefore, revising the principles of the classical system in its application to atomic world, we must, as it was first done by Werner Heisenberg, question the consistency of the old kinematic notions with the new ideas concerning the lower limits of any physical interaction.

Criticism of the Classical Notion of a Trajectory

Let us see first of all how the fundamental notion of the trajectory of a moving particle is being formed in the old mechanics. The analysis of such a kind can hardly be found in any book on classical mechanics for the apparent reason that, before the quantum crisis arose, the notion of the trajectory was always considered as self-evident and nobody really cared to go deeper into its definition. We would normally say that we form this notion by observing the motions of the particle in question and that we can directly *see* the line along which our particle is moving. But seeing involves the illumination of the moving object, and

we must be careful not to disturb the motion by the light falling on it. We know in fact that there is such a thing as the light-pressure, and the light reflected from the surface of the object will cause certain minute perturbations of its motion. Of course, in all practical cases the light-pressure is negligibly small. However, we are not discussing here the practical estimate of the trajectory but its validity as the absolute and fundamental notion of mechanics; in such cases nothing can be neglected and even the smallest disturbances must be carefully taken into account.

In classical physics, however, we can safely eliminate the disturbing effect of the illumination by reducing the intensity of light as much as we need to. In fact, the classical physics sets no limits for the amount of light-energy which can be reflected by a material body, and any amount of this energy, however small, is considered to be theoretically measurable by physical apparatus. We can use, for example, the following schematic procedure: Suppose we want *"to see"* the trajectory of a small stone thrown originally in a horizontal direction and falling down under the forces of gravity. To reduce as much as possible the disturbing effect of light-pressure, we can decide to illuminate the chamber in which the stone is moving only at those moments at which the observations of its location are actually being made.

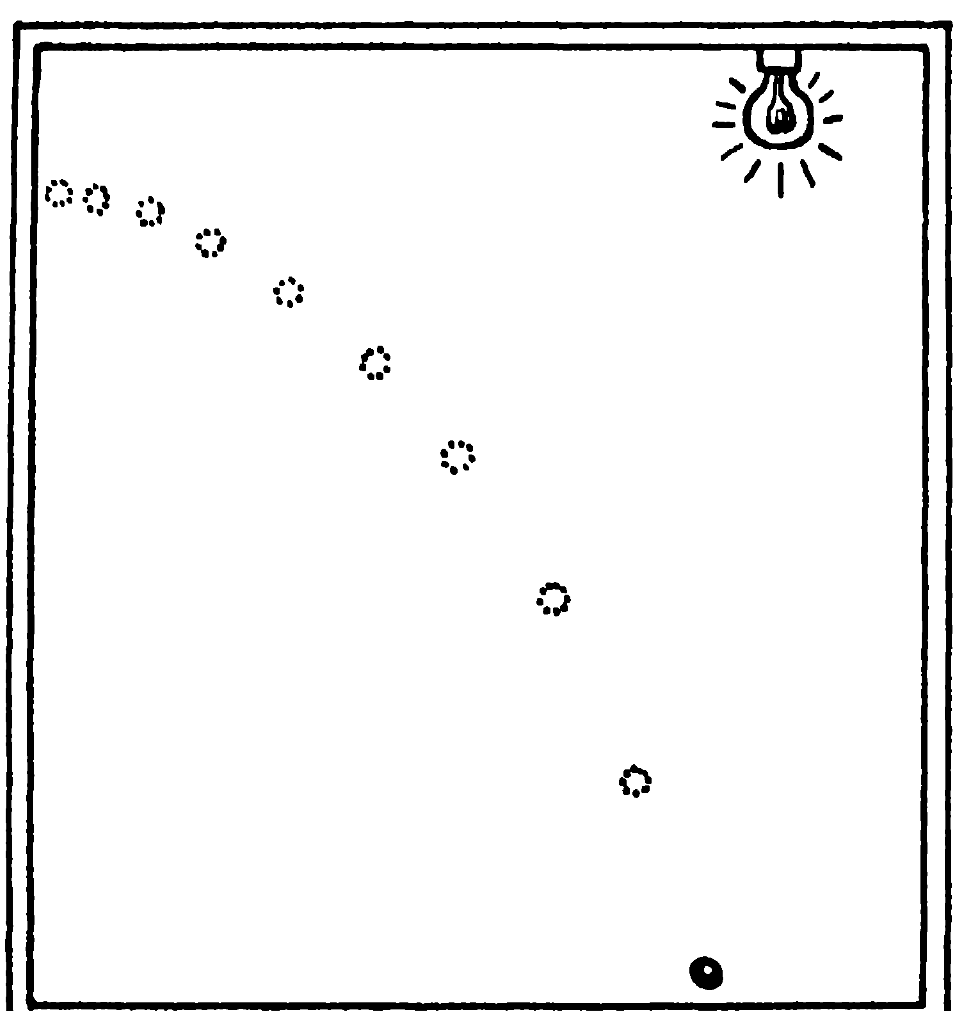

FIG. 1. AN IMAGINARY ARRANGEMENT DESIGNED TO ILLUSTRATE HEISENBERG'S CRITICISM OF THE CLASSICAL NOTION OF TRAJECTORY. THE MOTION OF A MATERIAL PARTICLE AS SEEN AT TEN SUCCESSIVE ILLUMINATIONS.

Thus we can flash the lamp, let us say, ten times during the fall, observing ten different locations. The intensity of the lamp and the period of illumination should be chosen sufficiently small to make the total disturbance due to the light-pressure as small as we want it to be; as we have seen, the classical physics set no theoretical limits in this direction. But ten points is not the trajectory, and to arrive at the notion of a continuous line as used in classical mechanics, we must be able to increase the number of the observed points without any limit. This can be also done, in principle, without increasing the distortion of the motion, by decreasing the brightness of the lamp parallel with the increasing number of separate flashes. Thus, going to the limit of infinitely large number of observations, and infinitely small intensity of illumination, we can finally arrive, theoretically, at the strict notion of a mathematical line representing the trajectory of motion.

There is one more point to be taken care of. It is well known from the principles of optics that the image formed by light reflected from a small body can never be made smaller than the wave-length of the light used. Thus, if we really want to get a mathematical line (provided we study the motion of a "material point") and not a more or less broad indefinite band, we have to use very short wave-lengths. Here again no hindrances are set forth by classical physics, as it recognizes the existence of arbitrarily short waves of arbitrarily

low intensities. All we have to do is to decrease the amplitude of light waves, increasing at the same time their frequency, and we shall have our line-trajectory "directly seen"!

All this analysis might seem very silly to the reader, and it probably would be silly if the classical physics were correct. But, as it is not difficult to notice, this "empirical construction of the trajectory-notion" contains the requirements which, being natural for classical theory, are not possible in the light of our new knowledge on quantum-phenomena. We have seen in fact that the light energy can exist only in form of certain definite portions, or light-quanta, and that the higher the frequency, the larger is the energy contained in each such portion. Thus the minimum amount of light which can be reflected from the moving object to make it visible is one quantum of energy, and the kick which it gives to the object can not be reduced any more. Of course, decreasing the frequency of light we can decrease the energy-content of the light-quanta; this will lead, however, to the increasing wave-length and consequently to the increasing "thickness of the trajectory" which we want to avoid. We see that, quantum-laws being valid, the exact notion of the trajectory can not be formed as the limiting case of optical observation.

The second method which we could attempt is the mechanical one. We can, for example, prepare a large number of miniature mechanical "shock-registering" apparatus, and spread them in the space through which the object in question will be moving. Those of the apparatus which have registered a shock will give us the idea of the track of the moving object, and increasing their number simultaneously decreasing their size we might arrive again at the limiting notion of the trajectory as a mathematical line. Here, however, just as in the optical method, the laws of quantum-physics prohibit us from arriving at the finite result. According to the Bohr's quantum conditions (formula 2), the energy required by such mechanical apparatus to "register the shock" will increase with their decreasing dimensions. Very small apparatus of this type will either not register the shock at all or take too much energy from the moving object. Thus we see that the mechanical method leads to the same result as the above-described optical one, and, as far as the quantum laws hold, there is no way to come to the logical definition of a trajectory as a mathematical line. The best we can do is to represent the track of motion by a more or less spread-out band, the thickness of which is defined by the value of the quantum constant "h." It must be clear, of course, that, because of the small numerical value of this constant, these "basic thicknesses" of mechanical trajectories are negligibly small in all practical cases, and become of importance only for such minute particles of electrons moving within miniature atomic system. For atomic electrons, however, the "thickness of trajectory" becomes comparable with the "diameter of the whole orbit," so that no further application of classical notions is any more possible.

The author emphasizes here a great danger that, after struggling through the last few pages, the reader will not quite lose his adherence to the classical notion of the trajectory. "I quite agree" —he would say—"that the observations might disturb the motion and even make the measurement of the trajectory quite impossible. But, if we do not light the lamp, and do not put the shock-registers on the way of the particle, there will be nothing to disturb its motion. Will it not then move along a strict mathematical line?"

Those who put such a question have not evidently understood the principal purpose of the above analysis. We have

not been discussing the possibility of observing the trajectory under the assumption that it is there. On the contrary, we tried to verify the necessity of the introduction of such a notion as a trajectory by means of primary observations of the outside world. And, as far as such a notion can not be strictly constructed, there is no sense of using it, only because Galileo Galilei and Isaac Newton introduced it, not knowing about the existence of the lower limits of physical interactions!

In a dark chamber with no "shock-registers" on its way, the particle will be subject to the same kind of indefiniteness in its motion, simply because such are the laws of nature which we only tried to exhibit by the observations described above. Probably the most striking demonstration of this fact can be seen in the processes of spontaneous or artificial radioactive transformations where a charged particle penetrates into or escapes from the interior of an atomic nucleus, "passing" through the regions of the space in which its potential energy is *larger* than its total available kinetic energy. It is clear that *from the point of view of classical theory no continuous trajectory, observable or not, can pass through this potential barrier surrounding the nucleus*, and yet the experiment teaches us that *the penetration still takes place*. We have here a typical example of the complete failure of the notion of the trajectory in the description of physical phenomena.

Uncertainty Relations of Position and Velocity

The fall of the notion of "the trajectory of motion" results also in serious changes of our views concerning the position and velocity of a material particle and leads to the conclusion that these two fundamental characteristics of motion can not be estimated simultaneously. In fact, if we could know exactly the position and the velocity of a particle at any given moment, we could calculate its prospective positions in the future and form in this way the notion of the trajectory. The analysis of the physical methods by which one could arrive at a simultaneous knowledge of the position and velocity of a moving particle brought W. Heisenberg to the result that any exact estimate of position will disturb the "knowledge" of velocity and *vice versa*. These considerations, very analogous to the above discussion of the "trajectory-observations," lead to the fundamental relation between the "uncertainty" of the position and that of the velocity of a moving particle. If we denote by Δx the "uncertainty" of position and by Δv the corresponding "uncertainty" of velocity, the "*uncertainty-relation*" can be written in the form:

$$\Delta x \cdot \Delta v \geq \frac{h}{m} \tag{3}$$

where m is the mass of the particle in question. The heavier is the particle, the better its positions, velocities and trajectories could be described by the methods of classical mechanics. It must be noticed here once more that the word "uncertainty" does not pertain only to the results of our measurements, but rather indicates the fundamental indefiniteness of motion as described by the laws of the new mechanics.

Uncertainty Relations of Time and Energy

We want to discuss here in some more detail the uncertainty relation between the time and energy, the relation which is generally less known than those between the positions and velocities. This relation can be written in the form:

$$\Delta E \times \Delta t \gtrsim h \tag{4}$$

and its importance was particularly emphasized by N. Bohr. It indicates that we can not know the exact amount of energy, together with the exact time when this energy was delivered. Macro-

scopically speaking, we would say that the bill for the electric energy used at a quite definite date must be necessarily uncertain by a negligibly small fraction of a cent.

The validity of this uncertainty relation can be demonstrated by an imaginary apparatus designed for the purpose of the exact measurements of both energy and time in contradiction to the above relation.[1] The "apparatus" consists essentially of a closed box inlaid with the ideal mirrors, and filled with a certain amount of radiant energy. Inside of the box is located an alarm clock connected with a photographic shutter in one of the walls. The clock (which is, of course, also ideal) can be set on a definite moment of time at which the shutter must be opened for one short moment, letting out some part of the radiation. Charging the box with the radiation and setting the alarm clock, we can close it entirely, separating its inside from the outer world. We have enough time now to measure its weight and, using the relativistic relation between the mass and energy, find out *exactly* the total amount of radiative energy in its interior. Another weight-estimate, executed after the date on which the alarm clock is set, gives us the final mass, and the difference corresponds to *the exact amount of energy radiated at the exact moment when the shutter was opened.* The fact that the box is completely closed, having the alarm clock inside, seemingly guarantees the absence of any outside perturbations produced by the process of weighting on the rate of the clock. It seems, at the first sight, that this "imaginary apparatus" would permit the exact

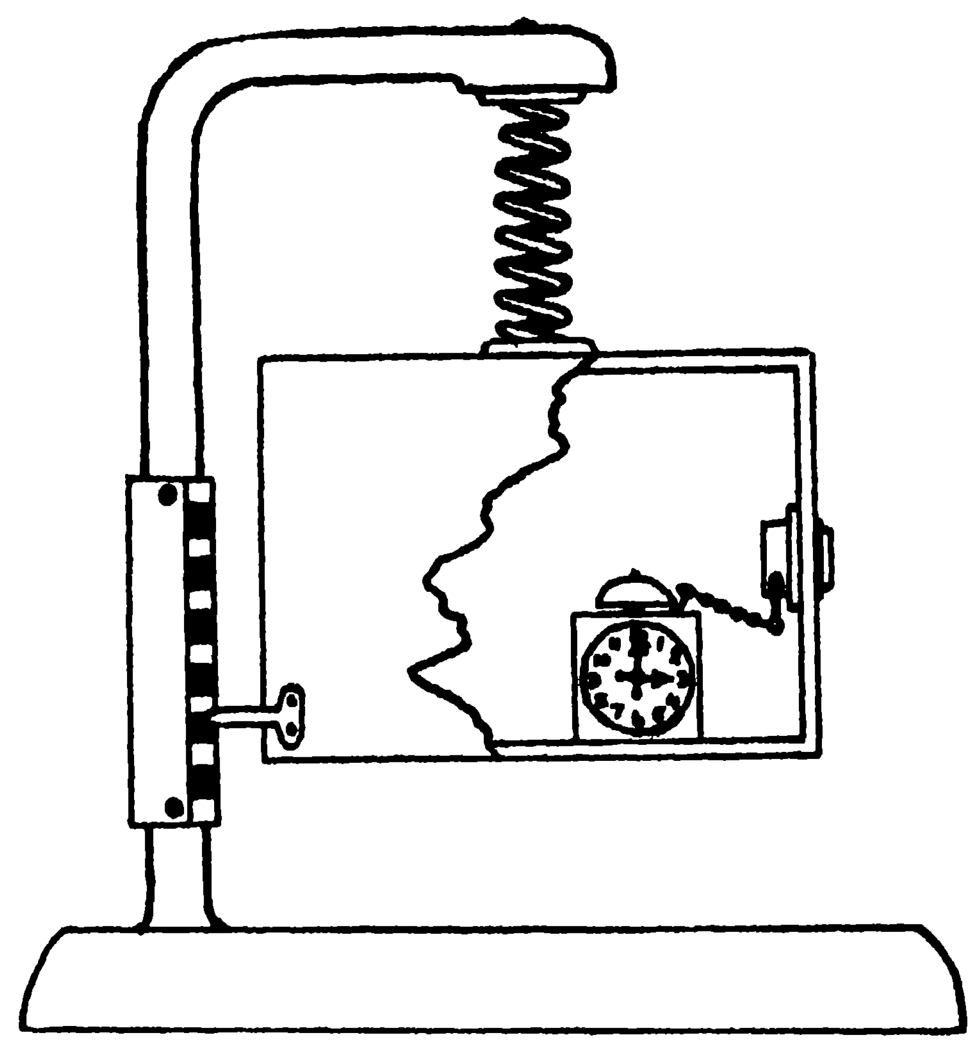

FIG. 2. AN IMAGINARY ARRANGEMENT DESIGNED TO ANALYZE THE POSSIBILITY OF THE SIMULTANEOUS MEASUREMENT OF THE ENERGY AND TIME. THIS TOY-MODEL WAS USED BY PROFESSOR N. BOHR IN HIS LECTURES ON THE INTERPRETATION OF THE UNCERTAINTY RELATIONS.

estimate of energy at the exactly given time, and thus would contradict the uncertainty relations of the quantum-theory.

However, it was indicated by N. Bohr that one can not measure the weight of the box without permitting it to move in the vertical direction in the gravitational field of the earth. In fact, whether we use an ordinary balance or spring scales (as in Fig. 2), the change of the mass to be measured will cause the vertical shift of the box together with the alarm clock fastened in its inside. But, according to Einstein's theory of relativity, any clock changing its position in the gravitational field would necessarily also change its rate. The resulting uncertainty of the time at which the shutter was opened is calculated to be exactly the same as it would follow from the fundamental relation given by formula (4).

Thus we see that, because of the relativistic effects which necessarily come in in any estimate of the mass in the gravi-

[1] The "apparatus" was proposed by A. Einstein at the Solvay Congress on Physics in 1930 as a possible contradiction to the Bohr-Heisenberg interpretation of the new mechanics. The explanation (given in text) as to why such apparatus does not represent any contradiction, and, on the contrary, supports the uncertainty relation, was given by N. Bohr at the same congress.

tational field, the uncertainty relations between the energy and time remain in force also in this case.

Uncertainty Relations for Large Bodies

As it was mentioned above, the quantum-mechanical uncertainty relations become of importance only for the particles of extremely small mass, and play no essential role in the everyday life.[2] It is therefore very interesting to see if there are any examples in which the deviations between the classical and quantum-mechanics could become large enough already for the bodies of normal size. Such examples can be really found, and one of them[3] will be discussed here. Let us take an ideally spherical elastic ball, say, one inch in diameter, and fix it rigidly on the surface of the table. If we place now another ball of the same size a few feet above the first one, and let it drop freely (Fig. 3), the classical mechanics would predict that the ball will jump up and down, all the time hitting the fixed ball exactly on the top.

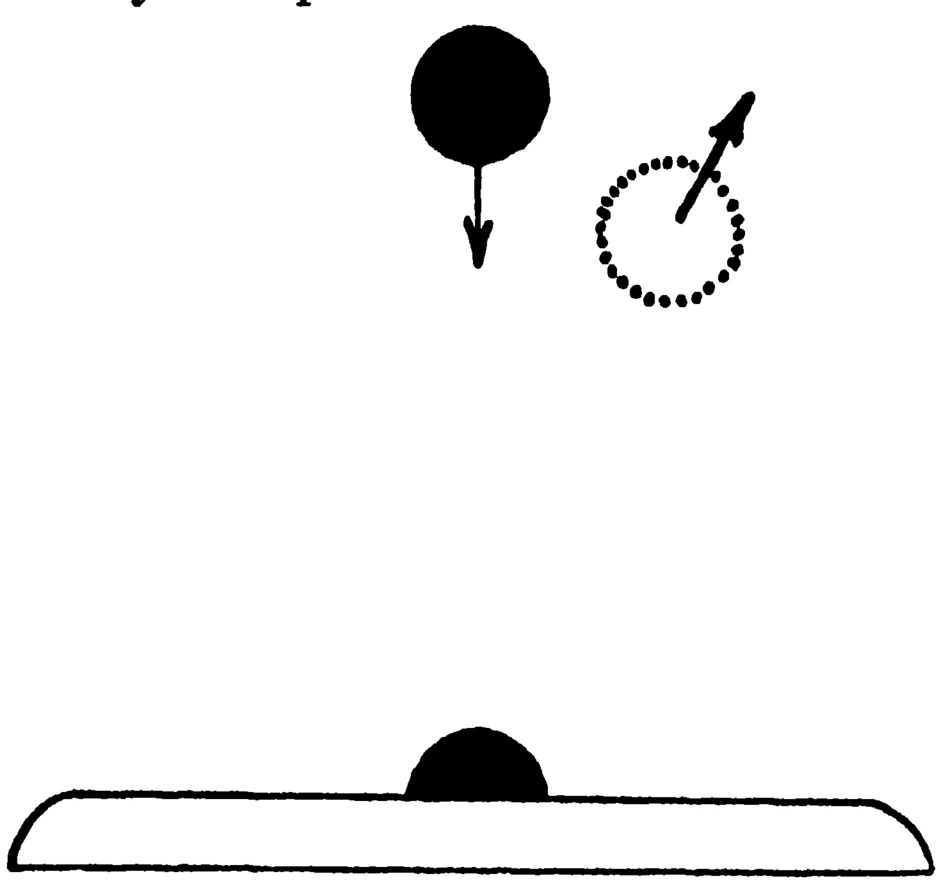

FIG. 3. IN THE NEW MECHANICS A STEEL-BALL DROPPED FROM A POINT DIRECTLY ABOVE ANOTHER RESTING BALL WILL JUMP ASIDE AFTER ONLY FEW BOUNCINGS. CLASSICAL MECHANICS WOULD NATURALY NEVER COME TO SUCH CONCLUSION.

According to the quantum-theory, however, the fundamental uncertainty of the location and velocity of the moving ball will cause the spreading-out of its trajectory. This will lead to uncentral hits and, after several bouncings, the ball will jump aside and fall on the table. The calculations show that, even in spite of the extremely small value of the quantum constant, the ball in the above example will be not able to do more than a dozen successive bouncings. Of course it is hardly necessary to mention that even the best steel-balls used in modern ball-bearings are by far not sufficiently spherical and homogeneous for such experiments, so that the proposed experiment can not be used for the actual demonstration. But it indicates that even in ordinary life the uncertainty relations of the new mechanics could play a certain role.

[2] The question as to how the "everyday life" will look if the quantum-laws would hold also for larger bodies could be found in the author's popular book, "Mr. Tompkins in Wonderland" (Macmillan Publishing Company, New York. 1940).

[3] Communicated to the author by Professor D. M. Dennison.

NIGHT OVER EUROPE

BY DR. RAYMOND B. FOSDICK
PRESIDENT, ROCKEFELLER FOUNDATION

THE mounting catastrophe in Europe and its effect on universities and laboratories in every country there—whether involved in the war or not—have necessitated modifications in the work of the Rockefeller Foundation. When the war broke out on the first of September, 1939, the foundation had 110 running appropriations in Europe, distributed in 22 different countries, and involving a total sum in excess of $4,000,000. A substantial part of these appropriations was for research in various scientific fields. Nearly $2,000,000 of the total was for work in Great Britain; approximately $750,000 was allocated to Switzerland; $330,000 each to France and Sweden; and the balance in smaller amounts ranging down to $3,500 in Finland.

In a number of instances work supported by these appropriations is being continued on a level that has been but little affected by the war. For example, Heilbron's research in organic chemistry, to which the foundation is contributing at Imperial College, London, is still going forward. Niels Bohr's work in biophysics at Copenhagen and Svedberg's studies with the supercentrifuge at Uppsala are also only indirectly disturbed. The Tavistock Clinic in London where the foundation is financing research in psychosomatic medicine, is proceeding, thus far at least, without serious interruption. Similarly, work in the general field of neurology, under grants from the foundation, is being carried on at the Universities of Brussels, Leiden, Lund, Oslo and Oxford.

Moreover, in spite of many unfortunate exceptions, there seems to be at least some effort in influential circles in Europe to insulate important scientific research work from the shock of war and to allow the laboratory men to continue with their tasks. In this respect, Europe is perhaps profiting by the tragic example of the last war when men like Henry G.-J. Moseley, the physicist; von Prowazek, the parasitologist; S. B. McLaren, the mathematician; Karl Schwarzschild, the astronomer, and a great host of fresh new leaders in every field of science were killed at the front. Of the 240 enlisted students of the École Normale Supérieure in Paris, an institution which supplies the French universities with professors, 120 were killed. Among the graduates of this school, 560 who were already professors in the universities were mobilized; 119 were killed. Of the students resident at the École Centrale des Arts et Manufactures, the most important engineering school in France, 179 were killed, together with 362 of the graduates.

This memory is still fresh in scientific circles in England, France and elsewhere, and efforts are being made, with the help of governments, to prevent in this war, as far as possible, the recurrence of such ghastly sacrifice.

But an attempt to keep scientific workers at their tasks, laudable as its motive is, meets but a small portion of the problem. At best it can salvage for the future only those whose promise is already indicated. Nowhere is there occult imagination to detect in a humble patent examiner a future Einstein, or to see in a tanner's son a Louis Pasteur. Darwin at 20 showed no particular promise in his studies; but he had courage and spirit and would have made excellent material for the front-line trenches. No human precaution can protect a nation

from the sacrifices which war levies upon future talent—the undiscovered scientists, the gifted minds, the intellectual and spiritual leaders upon whom each generation must build the hope and promise of the generation to come. The mortgage which war places upon the economic resources of a country is as nothing compared with the mortgage levied upon its future intellectual and cultural life.

In the war that is now being carried on in Europe the sacrifices and the processes of disintegration have already begun. We can see now something of the extent of the disaster. The University of Warsaw has ceased to exist. According to reliable reports, the entire Polish faculty of the University of Cracow is in a concentration camp. The Polish members of the faculty of the University of Vilna have been dismissed. Scarcely a year ago, the Moors, entrenched in the ruined University of Madrid, used the books from the university library as defenses in their rifle pits. The University of Prague has been shut by the German government. The University of Strasbourg has been torn from its site and planted in Clermont-Ferrand. For reasons of economy and because their students are in military service, more than half the universities of Germany are closed. The institutions comprising the University of London have been uprooted and scattered over a wide area in southern England. The 20,000 student population of the University of Paris has shrunk to 5,000. In all countries, whether combatant or non-combatant, the undiscriminating necessities of military mobilization have decimated faculties and student bodies alike. In many instances the ablest men on a faculty are being drafted for various types of war work. In other instances, on both sides of the fighting lines, laboratories hitherto devoted to the extension of knowledge, both in medicine and in the natural sciences, are being geared into the war machine. As a prominent governmental official on the continent recently said, "Science can now have but one object: to help win the war."

Perhaps the most frightening aspect of modern war is the intellectual blackout which it creates. One does not have to subscribe to H. G. Well's grim prophecy that "mankind, which began in a cave and behind a windbreak, will end in the disease-soaked ruins of a slum"; but certainly the night in Europe can not be long continued without the sacrifice of cultural values on so vast a scale that the chance of an enlightened and gracious life, not alone for this generation in Europe, but for the children and grandchildren of this generation, will be irretrievably lost.

Divided We Fall

One occasionally hears the statement that the trend of intellectual leadership is westward across the Atlantic. In proof of the assertion specific fields are mentioned, such as neurosurgery, astronomy, dentistry and perhaps orthopedics, in which America has won preeminent standing. But this argument overlooks the many fields in which leadership, certainly until the war began, was still in Europe and the many others in which genius and stimulation are as potent on one side of the ocean as on the other. In physiology, for example, it would be difficult to determine whether the leadership lies in Europe or in the United States. The same is true of anatomy and pathology. In fields like pharmacology, tropical medicine, ophthalmology, legal medicine, social medicine and dermatology—to mention only a few—leadership is unquestionably still in Europe, or was in 1939. In mathematics, the English are indisputably preeminent in analytic number theory; the Russians are making important contributions in topology and probability, the

French in algebra. America can not match the group of European scientists in the important fields of enzyme chemistry and the organic chemistry of natural products. Nowhere else in the world can one duplicate or even approach the coordinated and cooperating Scandinavian group which is focusing so many precise techniques of chemistry and physics on problems of biology.

If one is tempted to question the vitality of science in Europe, it is interesting to note that the most dramatic scientific development of the year 1939 originated there, i.e., the splitting of the atom of the heavy element uranium and its transmutation into barium and other light elements. This realization of the old dream of the alchemists was based upon results obtained in 1934 by the Italian physicist Fermi; but the disintegration products of uranium were first directly observed in 1939 by Hahn and Strassmann of Berlin.

America needs to be humble about this question of intellectual leadership. In spite of the anxiety and insecurity abroad during these recent years, of the six Nobel prizes awarded in science in 1939, five went to Europe and one to the United States. In countless ways we are dependent upon Europe for stimulation and leadership in relation to many segments of our intellectual and cultural activity.

If because of war exhaustion or chaos the universities and laboratories of Europe should be forced to suspend their fundamental activities for even half a decade, the consequences to the intellectual life of America would be immediate and disastrous. For scientific growth is almost invariably the result of cross-fertilization between laboratories and groups in widely separated parts of the world. Only rarely does one man or one group of men recite with clear, loud tones a whole important chapter, or even a whole important paragraph, in the epic of science. Much more often the start comes from some isolated and perhaps timid voice, making an inspired suggestion, raising a stimulating question. This first whisper echoes about the world of science, the reverberation from each laboratory purifying and strengthening the message, until presently the voice of science is decisive and authoritative. Thus, in the case of the breakdown of uranium during the past year, the early tentative questionings came from Rome; they were caught up at Berlin, were eagerly heard at Paris and Copenhagen, and then spanned the Atlantic and were seized upon here so enthusiastically that literally within hours, rather than within days, the critical experiments had been checked and extended at Columbia University, at the Carnegie Institution of Washington and in Lawrence's laboratory at the University of California.

Similarly, the amazing development and application of sulfanilamide—that beneficent gift to mankind—has been the result of a collaboration in which flags and boundary lines have been nonexistent. The first hint of it was discovered in Germany, oddly enough in connection with the commercial dye industry, and the drug was given the name prontosil. With this hint as a basis, in 1935 a German scientist—Dr. Gerhard Domagk—published the results of his experiments with mice under carefully controlled laboratory conditions, showing the extraordinary effect of prontosil on streptococcus. The Pasteur Institute in Paris then picked the matter up, and subjecting prontosil to organic analysis discovered that its activity was localized in one distinctive part of its molecular structure. This potent factor in prontosil, separated from the rest of the molecule, is what we now know as sulfanilamide. At this point Queen Charlotte's Hospital in London, with a grant from the Rockefeller Foundation,

tried the drug on women suffering from streptococcal infection associated with puerperal or childbirth fever, immediately reducing the death rate from such infections by 25 per cent. The Johns Hopkins School of Medicine was the next institution to carry forward the experiments, and in the last three years research on this drug has been developed, with brilliant results, in laboratories and hospitals on both sides of the Atlantic.

Achievement in science, more often than not, is the result of the sustained thinking of many minds in many countries driving toward a common goal. The creative spirit of man can not successfully be localized or nationalized. Ideas are starved when they are fenced in behind frontiers. The fundamental unity of modern civilization is the unity of its intellectual life, and that life can not without disaster be broken up into separate parts. If, as a result of the present cataclysm on the other side of the Atlantic, Europe freezes into an Arctic night, we shall not easily keep the fires lit in the universities and laboratories of America.

A SCIENTIFIC APPROACH TO RELIGION

By the Reverend JOHN S. O'CONOR, S.J.

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A STRANGE trend has emerged in recent years among certain writers on scientific subjects, a trend which is directly away from the goal towards which these writers profess to be aiming. Despite the fact that in general our concepts of natural phenomena are becoming more well defined and our knowledge of the world in which we live is growing continuously more extensive, as well as more definite, nevertheless in semi-popular books on scientific subjects, as well as in the more reputable journals, remarks dealing with any aspect of religion have for the most part been characterized by a lack of clear thinking and a vagueness which would lead one to conclude that the authors had chosen the reciprocal of the "h" of quantum mechanics as the limit of their indeterminacy rather than that minute magnitude itself.

In view of such articles as the recent one by Dr. K. T. Compton on "Religion in a Scientific Era," as well as a previous one by the late W. M. Davis on "The Faith of Reverent Science," both of which appeared in the SCIENTIFIC MONTHLY (January, 1940, and May, 1934), it seems appropriate to ask the question: Why do men of science refuse to approach the subject of religion from a scientific viewpoint?

Are they *assuming* without reason that faith and science are irreconcilable so that any attempt at reconciliation is doomed to failure from the start? Do they *postulate* without further examination that dogmatic religion is necessarily and essentially incompatible with the scientific method? Do they *deny a priori* that authority as a source of true knowledge must be abandoned *in principle?* If they do then they are no longer acting in the role of scientists but are subscribing to propositions the truth or falsity of which they show no evidence of having investigated.

The purpose of this article is to indicate not only that the scientific method of approach to religion is possible but as a matter of fact can be carried through to very definite and, perhaps to some, illuminating conclusions.

In order to avoid points of controversy inevitably connected with sectarianism this discussion will be conducted

along only very general lines, will be kept for the most part in the hypothetical mode, and the treatment will emphasize the form and method of approach rather than the matter or content of the various religious questions involved.

We should begin of course by defining religion in a manner acceptable to all participants in the discussion. However, even the etymological or nominal definition of religion is open to two interpretations, one which is based on the notion of a bond (from the Latin *religare,* to bind) and another which stems from the Latin derivative *relegere* or *religere,* to treat carefully, to ponder or meditate.

To get a least common denominator for all religions is a task beyond the scope of this consideration, yet an unbiased study of the history of religions and of comparative religion sustains a position which maintains that, despite the presence of admixtures such as ancestor worship and accretions of magic and witchcraft, the notion of a supernatural or supreme being is contained at least implicitly in practically all religions. So that on the first interpretation of the nominal definition of religion the idea of God is introduced historically as the term of the bond between man and a higher being, while on the second interpretation this supreme being appears, on the same historical basis, as the object of man's meditations.

The position taken here is one which is entirely unassailable on anthropological grounds. It starts with a *proof* of the existence of God as the First and Unproduced Cause of the universe. His supreme dominion by reason of this creation and conservation follows logically. It is the recognition by man, through his intellect, of this supreme dominion and the regulation of his life, through the power of his free will, in conformity with the manifest will of God that constitutes the true essence of religion.

To establish this position let me offer some hypothetical propositions, proposing them as the mathematicians propose their postulate systems, and then examine their consistency. If the existence of an intelligent being as the First Cause of the universe can be established by *rational scientific inference* from observed facts, if no other rational explanation of the produced intelligent beings existing in the world to-day has ever been found, then is not the only truly scientific position the one which accepts the existence of such a First Cause which we call God? The objection that such reasoning is based on unjustifiable extrapolation from the seen to the unseen is certainly not valid. Those who maintain it are driven back into a positivism which would throw out most of the conclusions of modern physics. How much of what we call scientific knowledge is based on observations of the senses *alone?* As has been said so often we have never seen and never will see a free electron. We do, however, see its *effects* in cloud chamber and on the recorder of a tube counter, and from the sensible evidence we *infer* (by the principle of sufficient reason) the existence of a cause of the track or pulse, which we name the electron. The knowledge of the existence of a First Cause is reached in the same manner, using the data derived from the senses and reasoning by the same laws of logic without which no scientific conclusion whatsoever could be reached.

In such an article as this there is not space for a detailed delineation of the cosmological argument for the existence of God, but I am absolutely convinced that any one who would give the same consideration to that proof, as outlined for example in William Brosnan's "God and Reason" (Fordham University Press) pp. 62 *et seq.,* as he would give to a line of argumentation found in the *Physical Review* or the *Proceedings of the Royal Society* would be forced to

admit that the cogency of this argument for the existence of God far outstrips that which is found in the reasoning which Chadwick uses to prove the existence of the neutron, which to-day is accepted as certain as any conclusion in the physical sciences.

Now for a second hypothesis: Granted the existence of an intelligent First Cause does it not follow that such a being must possess knowledge, and as the First Cause of all intelligent beings capable of intercommunication, He must also have the power of communicating His knowledge to other individuals? Is there any conceivable reason why such a being could not be the legitimate source of new knowledge for mankind? Any reason offered for the rejection of such testimony would also exclude all human testimony, and make a continuation of the recent rapid advances in science practically impossible. If we accepted in science only those conclusions which we have drawn from facts which we ourselves have observed how far would we get in any investigation? All mathematical, chemical and physical tables could be thrown away since on such a basis we would have to refuse to accept the values contained therein merely on the word of those who have determined them. Every time we wished to perform an experiment involving some additional constant we would have personally to determine its value.

On the contrary we are, as a matter of fact, accepting on faith many hundreds of items in both our daily routine as well as in our original researches. We are permitting authority to become a legitimate source of useful information for us.

It is futile to say that if we so wished we could verify all conclusions we so accept. The fact is that we do not do so, and in many cases could not, even if we wanted to do so. To take but one example, could we set the universe in reverse and reobserve the path of the light rays in the sun's gravitational field during the eclipses of 1919 and 1922? While it is true that the art of photography has given an objectivity to much physical data not enjoyed in the earlier days of science, even here we must accept the authority of the photographer inasmuch as we admit his requisite knowledge and mastery of the technique as well as his honesty in not retouching the film.

The conclusion is inescapable. If we admit the existence of a personal God we must also admit the possibility of revelation by Him to mankind. This admission is not to be made on the basis of some blind impulse which we dare not attempt to explain, but on the basis of judgments similar to those which we make about every-day matters—scientific and otherwise. Assent to the possibility of revelation is therefore reasonable and rational, and such is the *de jure* statement of the case.

As to the *de facto* situation; here again we have a problem which most scientists refuse to face in a scientific manner. Does God exist? Has he revealed Himself to us in any more direct manner than by His manifestations in nature? The students of Catholic *scientific* theology are convinced that the answers to these questions must be given in the affirmative, and they base their position on what they consider incontrovertible physical evidence—evidence that has been for a period not far short of 2,000 years, and still is acceptable to a large group of scholars.

Instead of investigating this evidence all but a few scientists are content with dismissing the entire problem by quoting the mistakes of a few misguided individuals, and they then refuse to pursue the matter further.

If all the articles on science were taken up with such topics as the mistaken notions of Newton concerning the

corpuscular nature of light or the persistent refusal of Lord Kelvin to accept, in the face of convincing evidence, Rutherford's theory of radioactive disintegration, the literature of physics would indeed be in a sorry state. And while such a situation does not exist regarding the topics which are the proper subject-matter for most scientific discussion, yet when questions of religion arise the attitude seems to change so as to preclude concentration on all but a few extreme and to-day scientifically untenable religious positions.

Because the electronic charge has been found to have a value different, by an amount greater than the admitted limits of experimental error, from the universally accepted value of 4.770×10^{-10} abs. e.s.u. we do not therefore completely discard the concept of the electron. Neither should we consider all religion "outmoded" because of the fanatical theological interpretation of a particular bizarre sect. Individual mistakes in arithmetic do not destroy the foundations of mathematics. Nor do the personal errors of whole schools of thought make all reasoning processes invalid. It is human to err as the ghosts of phlogiston and elastic solid ether theory can testify, but because of such errors science has not concluded that the continuation of the search for truth is futile.

Let me therefore present a further question which should again be answered from a scientific viewpoint: Granted the existence of God and the possibility of revelation and given the fact that certain groups of propositions are claimed by their defenders to be revealed truths, are not these claims entitled to the same attention and examination as is accorded to any other scientifically acceptable hypothesis?

The establishment of the tenets of true Christianity regarding revealed truths begins with a consideration of the authenticity and genuineness of scriptural writings as well as the historicity of the events recounted therein. From the valid testimony of these writings considered as historical documents we conclude legitimately not only to the existence of the person of Jesus Christ and the doctrines which He taught but also to the occurrence of certain special manifestations connected with His life and death. These special manifestations called miracles (such as resurrection from the dead) never have and never will receive an adequate *natural* explanation. They constitute mighty motives of credibility and irrefragable external proof that what is claimed to be Divine revelation is actually so. Nor can they be dismissed merely by the use of depreciatory adjectives, as has been done by the late W. M. Davis referred to above. No truly scientific refutation of the existence of miracles has ever been written because it would require a proof either of the non-existence of God or else put the author in one of two extremely uncomfortable and unscientific positions of having to either deny all and any form of physical law or, admitting such, he would then have to prove that any change in the admitted law would be forever and absolutely impossible.

Let me turn now from argument to illustration and propose an analogy which should add strength to the appeal for a scientific approach to religion. The scientific method is one which accepts facts and attempts to fit them into a theory or system. Agreement between fact and theory may establish or confirm the latter, but in all cases it at least renders the theory under test acceptable for further consideration. The facts of history pertaining to the teachings of Christ constitute a body of data. These have been moulded (under the guidance of Christ Himself) into a system, in such a way as to constitute an organism which displays the proper

functioning of the relations between theory and fact. Not only does this organization give a satisfactory interpretation of the facts on the basis of the theory which it represents, but this synthesis has been for 1,900 years and still is a workable system for millions of individuals the world over. So that to the pragmatic question, uppermost in the minds of so many to-day, revealed religion also gives a positive and favorable answer.

A further question must still be proposed: Does the system of revealed religion under consideration contravene any of the known facts of science?

The answer to this question will be given in the form of a challenge which may be stated as follows: No doctrine or dogma essential to Christian revelation and defined as such by either a general council of the Church of Rome or by any *ex cathedra* declaration of any pontiff of that same church has ever been found in contradiction to the certainly known facts of science.

We are of course assuming that the "conscientious objector" to the above proposition will investigate the meaning of Papal infallibility and *ex cathedra* definition before dragging out the already threadbare instance of the condemnation of Galileo.

Let us now turn to some of the views of Dr. Compton as expressed in the article referred to previously. In his summary Dr. Compton says, "Its (science's) whole tendency is to emphasize the fundamentally spiritual character of religion as representing the highest ideals of mankind *as opposed to theological rules, doctrines, theories, etc.*" (Italics mine.) Elsewhere in the article Dr. Compton speaks of "the dynamic character" of religion and "the need of a variety of religious denominations which emphasize different aspects of . . . the spiritual life." Regarding the changes in and diversity of religions, a distinction is necessary which may take its point of departure from the words of Dr. Millikan quoted in the same article. "I believe," says Millikan, "that essential and not dogmatic religion is one of the world's supremest needs." In this quotation a complete but gratuitous opposition is set up between a religion and its dogmas; the implication is that dogma is not essential to religion. But it is merely implication and not proof. If a religion holds nothing certain, nothing true, what is it worth as a religion—is it worthy of the name? It is of course true that religion, culture and knowledge itself may differ accidentally in different countries and in different periods of development, but it is obviously impossible for the same religion to teach essentially different doctrines at different times as it is absurd to claim that two religions which are in such essential opposition can both be true.

When we use a coordinate system to solve a problem, the important physical quantities in the problem are independent of our choice of a reference system. They are what are called invariants. The essential doctrines so frequently referred to with contempt as "dogmas" are the invariants of true religion. They remain the same throughout all transformations in space and time. Without them the adequate solution of the problem of the universe will never be obtained.

BOOKS ON SCIENCE FOR LAYMEN

EVOLUTION OF THE PHYSICAL UNIVERSE[1]

WHEN Milton decided to write an epic poem he chose a much more heroic subject than those of any of his predecessors who sang of "arms and a man" or other adventures of ordinary mortals. In "Paradise Lost" Milton sang of the rebellion of Satan and his horrid crew, "who durst defy th' Omnipotent to arms." For nearly three hundred years imaginations have been stirred by the superlative events he described.

Dr. Gamow has written on a subject that in the field of the physical sciences makes the ultimate demands upon the imagination and credulity. His work is not based upon theology and mythology, but upon carefully reasoned theories derived from observations. He writes with authority, for he himself has contributed important parts to the great theoretical structure that has been erected.

Naturally Dr. Gamow could not start with the birth of our sun and other suns, for the past as well as the future must be inferred from the present. He first raises the question of the origin of the sun's heat, a subject that has been puzzling scientists for eighty years since it was first realized that heat has the property of quantity, the same as mass. He passes in review the inadequate contraction theory and develops the recent theories of the liberation of energy through the transmutation of the elements, especially hydrogen, including the carbon-nitrogen cycle.

Inevitably theories of the origin of the heat of the sun apply in general to the heat of the stars. For the first time a fairly coherent theory of the evolution of the stars has been worked out. It is interesting that the lives of these great bodies are determined by the properties of atomic and subatomic particles of which they are composed, somewhat as the lives of the largest animals depend upon the microscopic and submicroscopic organisms to which they are hosts. Following the stars backward, Dr. Gamow finds a time when they were greatly expanded and cooler and were much closer together. In fact, he places their birth at about two billion years ago. He follows them as they contract and increase in temperature, for a time mostly as a consequence of their contraction, and later as a consequence of the transformation of elements. According to this theory, our sun is getting hotter, though very slowly, and will eventually radiate so much energy that life on the earth will be destroyed. Eventually, however, it will pass a climax, the climax depending upon its mass, and then decline in size and brilliance. Then "after another long period, our sun will turn into a giant lump of lifeless matter covered with eternal ice and surrounded by a system of frozen but still faithful planets."

This book is excellently and interestingly written, with many a whimsical turn that will prove that the most exacting scientists away from their specialties are quite as human as other folk. The drawings by which Dr. Gamow has illustrated many of his descriptions and arguments are equally entertaining and instructive. Intelligent readers who find pleasure in reflecting on the great problems of the origin and destiny of the universe, of which this earth is a trivial part, will greatly enjoy this book and will be brought up to date by reading it. Has the final answer to the origin, evolution and destiny of the universe at last been found? Some advance has been made toward the answer to this problem, but there probably will be no *final* answer.

F. R. M.

[1] ***The Birth and Death of the Sun.*** **By George Gamow. Illustrated. xi + 238 pp. $3.00. 1940. The Viking Press.**

THE SOCIAL SCIENCE ROLE OF GENETICS[1]

THE intimacy of the relations between the social and biological sciences is fortunately increasing rapidly. Any effort to clarify their mutual interdependence is of value not only to the sciences themselves but to humanity as a whole. The biologist frequently requires to be reminded of the significant human, social and economic implications of his work. The social scientist, working with that most complex and baffling of organisms, human society, obtains much useful data and even more valuable techniques and disciplines from the biologist. When sociology finally divorces sterile philosophy to wed science, the offspring may prove to be the salvation of mankind. To forget that we are biological is to be no longer logical.

Biology, medicine and sociology are inseparable. The first deals with the fundamentals of life, the second with man as an individual and the last with the interrelations of man. A new text-book by Professor Burlingame, of Stanford University, has as its primary objective the correlation of these three fields of study by the common denominator of heredity. Each living organism carries the blessings and curses of its ancestry: it is what it is because heredity and environment jointly control development. The principal aims, as stated in the preface, include a brief introduction to the biology of reproduction, the fundamentals of genetics and a discussion of how and where this knowledge is applicable to social problems in the broader sense. These objectives are attained.

Though the author claims that this is a text-book rather than a comprehensive treatise, the book is so splendidly organized, the facts are so well selected and the theoretical discussion so thoroughly thought out that the volume makes fascinating reading independently of any "course." How rare are the texts of which such may be said! The style is excellent: clear, concise and free from ambiguity. The discussions of the rôle of heredity in the theories and practices of government and mass movements of mankind (war and/or migration) are largely speculative. As such they are provocative of thought by revealing a fresh perspective. Chapter XIX, "Heredity and Medical Problems," and XX, "Heredity and Insanity," are the weak links in this otherwise excellent chain. Here the weakness lies in the lack of clinical knowledge. Those portions dealing with the socio-economic aspects of medical practice are stimulating reading.

The illustrations are well chosen and aid greatly in clarifying the mechanics of heredity to non-biologists. Typography, paper and binding are all of a high order. The book is highly recommended to all those thinkers concerned with the bio-social future of mankind: physicians, biologists, social scientists, philanthropists and statesmen. The more our students, who are the future citizens and voters, understand the implications suggested by this book the more secure and progressive is the future of democracy.

EDWARD J. STIEGLITZ

[1] *Heredity and Social Problems.* By L. L. Burlingame. Illustrated. xi + 369 pp. Price $3.50. 1940. McGraw-Hill Book Company.

TRY IT YOURSELF[1]

IN twenty brief chapters, Dr. Freeman takes his readers over a considerable part of physics—from "The Stuff the World is Made of" to "Light and Sight." This survey is neither heavy nor trivial. It has neither the ponderosity of the academic specialist nor the frothiness of the science-magician. With restrained enthusiasm, the author introduces a large number of important principles of physical science by means of illustrations that

[1] *Invitation to Experiment.* By Ira M. Freeman. 238 pp., 114 illustrations. $2.50. 1940. E. P. Dutton and Company.

are within the mental horizon of nearly every person. The familiar is skilfully made to reveal the general.

One of the attractive features of the book is the numerous illustrations, both reproductions of photographs and line drawings. The photographs are appropriate and the line drawings are excellent, often superior. Some of the photographs show great commercial applications of the principles under discussion, such as an airplane ready for testing in a full-scale wind tunnel and the huge stabilizing gyroscope installed on an ocean liner. The drawings often illustrate experiments that any one can make. In fact, they justify the title of the book, "Invitation to Experiment." They are not only illustrative but are very interesting.

Perhaps Dr. Freeman acquired an interesting and lucid style by writing scripts for broadcasts. At any rate, the style of his new book is excellent. He has proved that fundamental science can be made clear and interesting without burdening the reader with a large number of unfamiliar words. Although his sentences are simple and direct they are so varied in length and structure and tone that they are never monotonous.

As Dr. Freeman says in his Introduction, he addresses himself to the general public. After remarking that a considerable amount of interpretation of science has been published during the past few years, he says: "Much of this literature has tended to dwell unduly on the latest and most imposing achievements of pure and applied science—the whipped cream of the subject—supplying only sketchily if at all an exposition of the fundamental concepts on which the imagination-stirring fruits of modern scientific achievements are based. . . . Certainly—with a little explanation—a lump of iron is fully as remarkable as a filterable virus or the latest plastic, and gravitation is no less wonderful than cosmic rays or vitamins."

F. R. M.

AN ACCOUNT OF THE MARINE WORLD[1]

In "The World under the Sea" the author covers admirably the varied and interesting science of oceanography. Five chapters devoted to physical oceanography give the high lights of our present knowledge on such subjects as submarine geology, earthquakes, volcanoes, temperatures, chemistry, light penetration, tides and currents, including methods and devices used for deep-sea exploration. Diagrams show the profiles of the various oceans and reveal, for example, the immense uniform expanse of the ocean floor in parts of the Pacific in contrast to the deeps and plateaus of the Atlantic.

Thirteen chapters treat of life within the sea, from the shores' edge to the oceans' abyss. This is discussed broadly and well. An account is given of the remarkable abundance and variety of life on the continental shelf and of the mysterious populations in the great depths where total darkness prevails. In order are described the plant life—bacteria, diatoms, seaweeds, the animal life, ranging from the lowly forms such as foraminifera, sponges, jellyfish, corals, worms, to the highest invertebrates—crustaceans, molluscs, starfishes, etc., and, finally, to the vertebrates—fishes, reptiles and mammals. Birds are given a passing mention, for, as the author states, they might well occupy a volume by themselves.

The book is well illustrated, concludes with a brief discussion of economic factors and has a good index. The reader is sure to find this treatise most interesting and instructive.

WILLIAM C. SCHROEDER

[1] *The World under the Sea.* By B. Webster Smith. Illustrated. xix + 230 pp. 1940. D. Appleton-Century Company.

SIR JOSEPH JOHN THOMSON

THE PROGRESS OF SCIENCE

THE WORK OF SIR JOSEPH JOHN THOMSON

THE father of the new era of science has joined his ancestors in the great family of the immortals whose race began with Newton.

Rich as has been the life of science since Thomson discovered the electron, its span has been but short in years. But short as it has been, it has seemed even shorter; for new domains have opened up with such speed that there has been no rest to count the passage of time, and even to-day one is apt to think of the beloved J. J. as a young man, and to be almost startled to recall that he died (August 30, 1940) at the ripe age of 83.

Thomson was symbolic in part of the old school of physics and in part of the new. Like Newton, Kelvin, Maxwell and Rayleigh, with Faraday standing as an exception, he was thoroughly trained in the technique of, and constructive in, mathematical physics, and this great power stood always in readiness to serve the needs of interpretation of his experimental researches. Unlike these great predecessors, however, whose interests ramified over all fields of natural philosophy, he symbolized that era of specialization which has evolved more or less as a necessary consequence of the ever-increasing complexity in all fields of physics.

It was in 1884 that Thomson became Cavendish professor of physics at an age —28 years—so unusual for such distinction, particularly in those days, as to bring forth from a well-known college tutor an utterance to the effect that things had come to a pretty pass in the university when mere boys were made professors. He was precipitated into this realm of responsibility from a school of physics which seemed to have attained the goal of all that was ever likely to be possible, a school in which many were busy in polishing up the work of their predecessors by adding a decimal point here and there. In this school a certain pedantic spirit of caution had evolved, a spirit which feared lest science should become contaminated in the slightest degree by speculation. The ideal was to confine attention as far as possible to the experiments themselves, and drag from them such light in the matter of understanding and correlation as they were capable of revealing, by a more or less empirical dissection with strict adherence to use of the surgical instruments provided by the mechanisms of mathematical analysis. Suggestions of inner structures to facilitate the reasoning were viewed with suspicion. One was allowed to speak of a *current of electricity* as a convenience of language, but woe unto him who implied that he was thinking of anything moving along the wire. Even Maxwell, the father of mathematical electrodynamics, hesitated to speak of *particles of electricity;* and when for convenience in discussing electrolysis he is constrained to speak of a molecule of electricity, he says that the phrase is out of harmony with the rest of his treatise. One was permitted to speak of atoms and molecules more or less in whispers, but the discipline imposed upon one's thoughts is symbolized by the great Kelvin's complaint made, in later years, against the new ideas of atomic structure and disintegration, a complaint which maintained that the very word "atom" implied that the entity was indivisible. The atom was given a name—a name considered safe to protect it from heresy —and it was expected to live up to its name.

There was an exception to the unseen things which were forbidden. Physics, feeling the need of something in which to transmit light waves, had come to admit an aether, and classical dynamics

occupied such a respectable place as the vassal of all the mathematicians since Newton, that it was regarded as a highly proper agency to operate the aether. Physics had a merry time for many years trying to make an aether which could be worked by the dynamics or a dynamics which would work the aether. The desire for a substantial aether, and a conventional one, is illustrated by such remarks as that of the eminent contemporary of J. J. Thomson, Arthur Schuster, who, as late as 1904, writes: "The study of physics must be based on a knowledge of mechanics, and the problem of light will only be solved when we have discovered the mechanical properties of the aether." Writing, in another place, of Maxwell's equation, he remarks: "The fact that this evasive school of philosophy has received some countenance from the writings of Heinrich Hertz renders it all the more necessary that it should be treated seriously and resisted strenuously."

Thomson himself was sensitive to the call of the new for contact with the old, and following Faraday, but aided by a more comprehensive mathematical knowledge, he spent much effort in seeking to interpret Maxwell's mathematical framework in terms of the seemingly more concrete properties of "tubes of force." His earlier writings on "Applications of Dynamics to Physics and Chemistry" and his "Treatise on the Motion of Vortex Rings" show close contact with the type of investigations of his mathematical predecessors, but even in the early eighties we find him interested in the properties of moving electrical charges, regarded as concrete entities. After his election to the Cavendish professorship, his interests centered rapidly upon that field of conduction of electricity in gases in which he and his many eminent students did so much to write that new chapter in the history of science which gives immortality to his name.

Like most radicals in physics, Thomson became quite conservative in his own radicalism, and did not look with any great favor upon the birth of even the Bohr-Sommerfeld theory. In spite of this, in seeking ways of correlating nature within the frame of the philosophy of classical electrodynamics, he was bold in speculation, even beyond the courage of those who viewed a complete break with the past with equanimity.

Thomson's "Recollections and Reflections" contains an interesting side light upon his attitude towards creative thinking. He writes: "There is no better way of getting a good grasp of your subject, or one more likely to start more ideas for research, than teaching it or lecturing about it, especially if your hearers know very little about it, and it is all to the good if they are rather stupid. You have then to keep looking at your subject from different angles until you find the one which gives the simplest outline, and this may give you new views about it and lead to further investigations. I believe, too, that new ideas come more freely if the mind does not dwell too long on one subject without interruption, but when the thread of one's thoughts is broken from time to time. It is, I think, a general experience that new ideas about a subject generally come when one is not thinking about it at the time, though one must have thought about it a good deal before."

Thomson symbolizes, perhaps more than any other physicist, the creator of a "school" of physics. When one thinks of him, it seems impossible to separate him from this school. Beloved by his many illustrious students, he seems rather as an elder brother among them, a brother in a family which will forever remain illustrious in the annals of science.

W. F. G. SWANN,
Director
BARTOL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE

LEONARDO DA VINCI EXHIBITION AT THE NEW YORK MUSEUM OF SCIENCE AND INDUSTRY

THE scientific investigations and achievements of Leonardo da Vinci are graphically demonstrated at the New York Museum of Science and Industry in an extensive exhibit which will be on view for the rest of the year. Dr. Frank B. Jewett, president of the Museum, recently paid the following tribute to da Vinci:

For a long time the greatness of Leonardo da Vinci rested on a few works of art which survived the accidents of time. Centuries rolled by, almost to the threshold of our own day, before the world began to stir with an awareness of the immense debt it owed him as a scientist and inventor. Even to-day, indeed, few realize the extent to which the industrial civilization of America traces its spiritual beginnings to his amazing genius.

Leonardo was born in Vinci, Tuscany, in 1452 and died at Colux, France, in 1519. Beside his few major works of art, which include the *Mona Lisa* and the *Last Supper*, the record of his achievements consists of some seven thousand sheets covered with drawings and notes. These pages show that all his life Leonardo was obsessed with two aims: to perfect his powers of artistic expression, and to find the order in nature which would enable man to harness its forces in his service. Nothing that came within the range of his faculties was alien to him. He looked on all creation, and he challenged its mystery with the prodigious power of his mind.

Neither Leonardo's studies, nor his inventions, proceeded in any organized or systematic fashion. Instead, following the course dictated by the chaotic events of his life and times, he ap-

PARTIAL VIEW OF THE EXHIBITION OF LEONARDO DA VINCI'S WORK

AT LOWER LEFT IS ONE OF THE FAMOUS FLORENTINE'S DESIGNS FOR A WATER WHEEL. IN THE FOREGROUND IS A MODEL OF ONE OF HIS MULTIPLE-STRAND PULLEYS. ALONG THE STAIRWAY ARE REPRODUCTIONS OF SKETCHES FROM HIS NOTEBOOKS, WHILE ABOVE IN THE BACKGROUND IS A GLIMPSE OF THE MILITARY MACHINES SECTION.

LEONARDO DA VINCI—A SELF-PORTRAIT

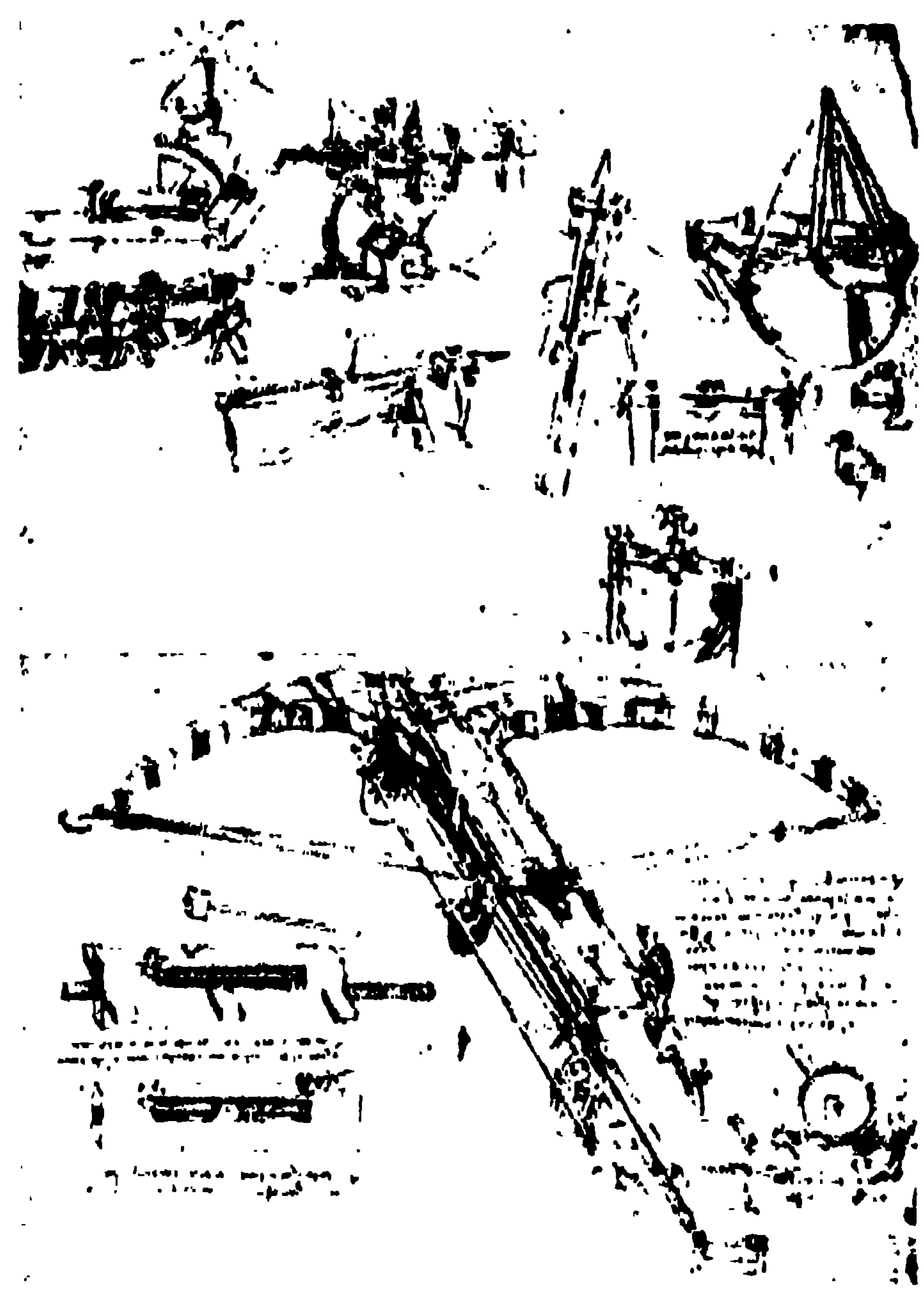
plied himself now to one, now to another science. In his last years, he did attempt to edit and set his manuscripts in order, but before he was able to complete this task, death put an end to his gigantic endeavors.

"Science," wrote da Vinci, on one of those seven thousand pages left as his heritage to humanity, "is knowledge of the things that are possible, present and past; prescience, knowledge of the things which may come to pass." Thus, in a reflection jotted down at random, did one of the greatest geniuses the world has ever known, define for himself the limitless territory he had set himself to explore."

The exhibition, part of a comprehensive display of Italian scientific inventions held in Milan during the summer of 1939, consists of approximately 200 working models, built from original sketches, diagrams and notes. The models were carefully reconstructed by Italian technicians and artisans in the spirit of Leonardo's own time, even the raw materials employed in their making being as close as possible to that available to workers in the fourteenth and fifteenth centuries. Many of the models, according to the scholars and scientific experts who collaborated in the work of reconstruction, can stand comparison with the most modern techniques and inventions, and not a few of them resemble certain of those to be seen to-day in any up-to-date machine shop or factory.

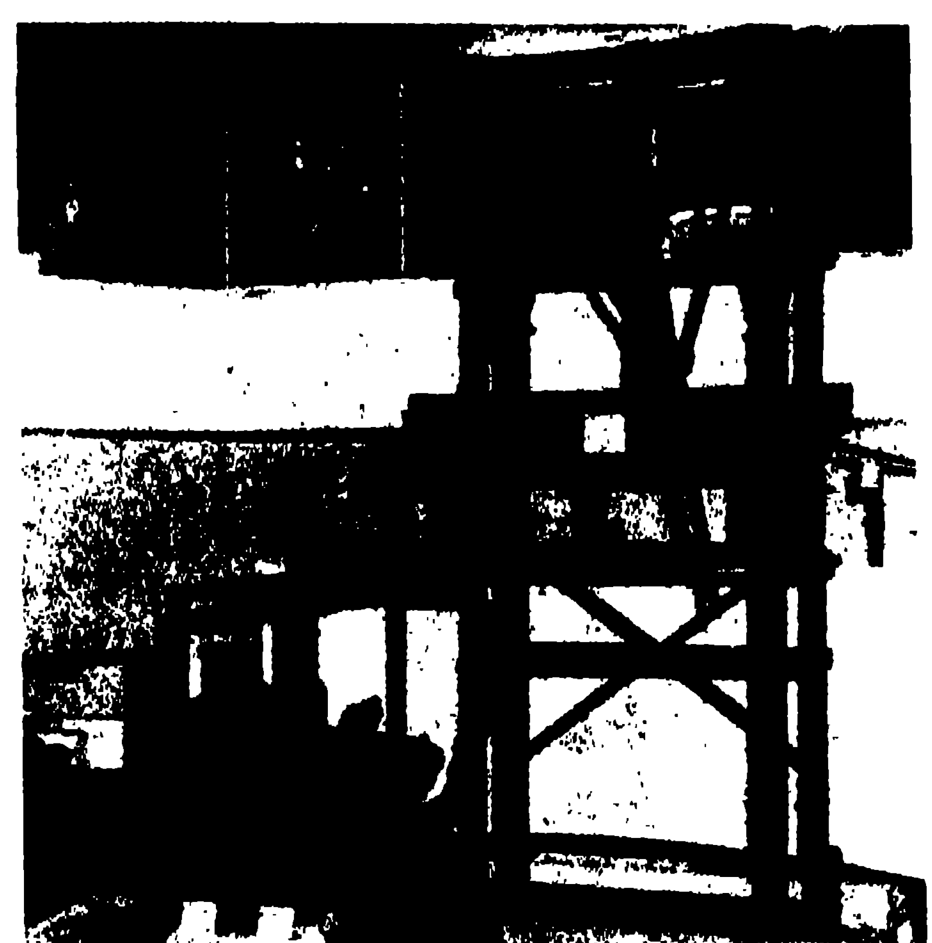
The various exhibits in the collection show that Leonardo da Vinci's many-sided scientific curiosity led him into practically every field of human interest. They deal with anatomy and botany, with astronomy and geology, with mathematics, architecture, aviation, hydraulics, military engineering and with other fields. There are ten models concerned with flight in the exhibition, including models of flying machines, a parachute; an "aerial screw" that appears to some observers to have been based on the principle of the helicopter and is said to be the "ancestor of all modern airplane propellers;" and a number of instruments intended to gauge wind velocity and humidity.

Seven models have to do with city planning, some of which—dealing with the problem of traffic regulation—bear



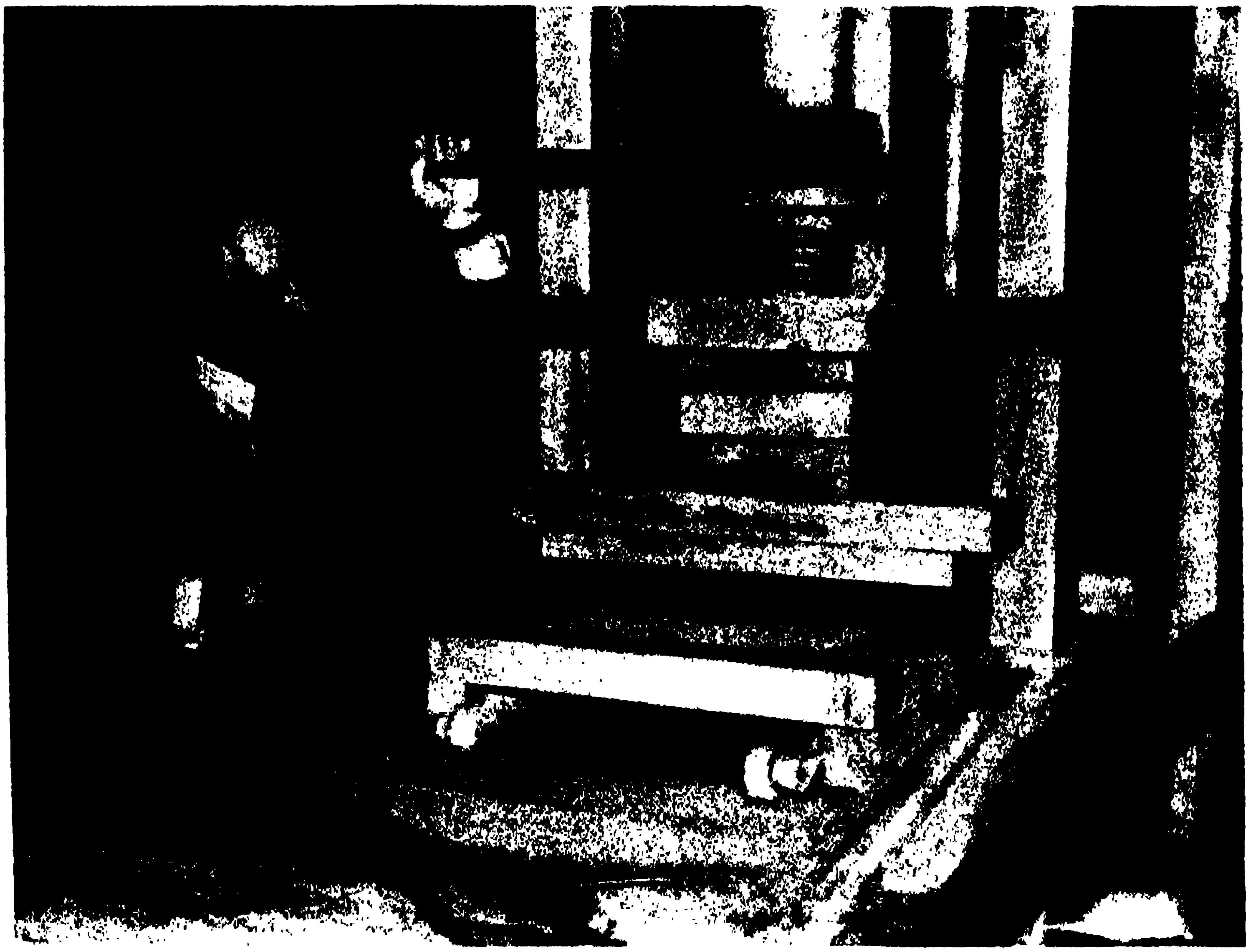
A PAGE FROM DA VINCI'S NOTEBOOK

SHOWING SOME OF HIS DESIGNS FOR MILITARY MACHINES. BELOW IS SEEN A DEVICE FOR HURLING PROJECTILES OF VARIOUS TYPES, MADE TO OPERATE IN THE MANNER OF A CROSS-BOW.



SCALE MODEL OF A "WATER LIFT"

DESIGNED BY LEONARDO DA VINCI FOR USE IN CONNECTION WITH THE BUILDING OF A CANAL FROM FLORENCE TO THE SEA. THIS WORKING MODEL IS ONE FIFTH THE SIZE OF THE ORIGINAL.



WORKING MODEL OF DA VINCI'S CONCEPTION OF A MOVABLE PRESS

IT WAS DESIGNED BY DA VINCI NEARLY 100 YEARS BEFORE THE ONE INVENTED BY JOHN GUTENBERG IN GERMANY, WHO IS GENERALLY CREDITED WITH CREATING THE FIRST MOVABLE PRESS.

a marked resemblance to designs offered by modern architects as a solution of the problems of congestion which beset the large cities of to-day. The largest of the models in this group, that of the "Ideal City," is close to twelve feet long and some ten and a half feet wide. In addition, there are 22 plaster models of miscellaneous subjects in the architectural display.

Nineteen models are concerned with various aspects of hydraulics, showing Leonardo's ideas relating to the building of canals, dams, sea locks, basins, bridges and the like. One of them shows an ingenious gate in a lock. When the capstan in the background is turned, the gate slowly drops into a pocket, allowing the water to pass into the canal. This method of raising or lowering boats around natural obstructions is, of course, much the same as that in use to-day.

Among the miscellaneous mechanical inventions are a sheet metal machine or "rolling mill"; a variable speed drive, forerunner of our modern automobile transmission; a model embodying the principle of the modern ball bearing, for elimination of friction in moving parts; an automatic roaster, the idea for which da Vinci conceived while watching an inn keeper laboriously turning a roasting pig on a spit; two printing press models; a screw-threading machine; a device which forecasts the modern steam shovel; a steam engine; an automatic saw, forerunner of the modern buzz saw used in lumber mills; and a number of others. Machines for work in the field of optics, a flying spindle, a paddle wheel ship, a valve action pump and twelve other types of pump, a cloth shearer and an automotive cart equipped with differential gears to transmit power to the rear wheels are

some of the other exhibits of high interest.

Some thirty or more models are related to da Vinci's studies of military and naval operations, made while he was military engineer in the service of Caesar Borgia. They include a design of a fortress containing underground passages, bridges for use in military operations, various types of guns, an armored ship, a double-hulled vessel and apparatus for breaking and piercing the hull of an enemy ship, also a diving apparatus which the great inventor is said to have left incomplete because he feared that "man's wickedness and ferocity" would result in its misuse.

The various models have been set up to show how their originals developed in da Vinci's mind. To this end, an enlarged reproduction of that page from da Vinci's notebooks containing the sketches and diagrams of each machine or device has been placed in the background behind each model. In some instances, numerous drawings are exhibited, presenting various phases of his studies, notably in the section devoted to his work in aeronautics, where a great variety of his notes and sketches dealing with his observations of the flight of birds are shown.

Each of the two main stairways leading to the mezzanine levels of the Museum is lined with drawings which further emphasize the diversity of Leonardo's interests and artistic genius. Here are seen sketches of the heads of madonnas, of animals, of mechanical conceptions, of flowers and plants, hair arrangements, allegorical subjects, mathematical studies, costumes, draperies, caricatures and a host of others. Not infrequently, little drawings of wholly unrelated subjects will appear on the same page, indicating the speed with which many different concerns moved through the master's mind.

Not the least interesting to visitors to the exhibition are the reproductions of notes written in da Vinci's curious right-to-left script, requiring the use of a mirror before the words could be read. Two sentences from his notes have been reproduced on the walls at the foot of each main staircase, faithfully copied in this "mirror writing." One of them reads: "Every action of nature is made along the shortest possible way," and the other, "Oh Lord, thou sellest us all good at the price of labor."

The installation of the exhibition was supervised by Dr. Giorgio Nicodemi, director of the Department of Fine Arts of the Common of Milan and Director of Museums in the Sforza Castle, who came to New York with two technicians. Dr. Nicodemi is one of Italy's outstanding authorities on Leonardo da Vinci, and has written many books on the great Italian scientist and painter. He is a member of the Royal Commission for Publication of Texts on Leonardo da Vinci.

M. C. M.

EIGHTH SUMMER CONFERENCE ON APPLIED SPECTROSCOPY

The eighth annual summer conference on applied spectroscopy was held at the Massachusetts Institute of Technology during July 15 to 17, with 250 biologists, chemists, metallurgists and physicists taking part, as well as a few representatives of other sciences. Thirty papers were delivered during the three all-day sessions, with discussion periods following each paper.

The amazing power of spectroscopic methods to furnish information about matter in almost any state was responsible for the gathering together of representatives of so many sciences in one group. To the astronomer the spectrograph has revealed much about stars and nebulae as units of study. To the archeologist it can contribute information regarding objects fashioned by human hands, as shown in a paper by Dr. Daniel Norman, of the New England Spectrochemical Laboratories, reporting on a spectroscopic comparison of Central American and Asiatic jades. The physicians of the audience were particularly

interested in a discussion of the relative potencies of various Vitamin A materials, as determined spectrographically by Dr. R. L. McFarlan, of the United Drug Company; in an analysis of Saratoga Springs mineral waters by Dr. Lester Strock of the Saratoga Springs Commission; and in a paper on the absorption spectra of hemoglobin derivatives by Dr. David L. Drabkin, of the University of Pennsylvania.

Passing from human to plant health, the program contained much to interest the agriculturist; in particular a comparison of the metal content of the leaves of various varieties of grapes, reported by Dr. B. C. Brunstetter, of the U. S. Department of Agriculture; and studies of the bearing on plant growth of metallic constituents of the soil, as determined with the spectrograph, presented by Dr. L. H. Rogers, of the University of Florida.

Entering the realm of the molecule, there were various papers of interest primarily to chemists, such as the spectroscopic study of thionine solutions presented by Dr. L. F. Epstein of the Massachusetts Institute of Technology, the spectroscopic determination of atmospheric ozone by Dr. Brian O'Brien, of the University of Rochester, and a description of a new spectrophotometric method of measuring fast reactions by Dr. F. Karush, of the Massachusetts Institute of Technology.

The physicist, concerned with atoms and their behavior, was represented by Dr. W. F. Meggers, of the National Bureau of Standards, who discussed the physical basis of spectrographic analysis; by Dr. O. S. Duffendack, of the University of Michigan, who reported on measurements of temperatures in spectroscopic sources; by Dr. M. F. Hasler, of the Applied Research Laboratories of Los Angeles, who discussed a special type of arc for spectrochemical use, and by a number of others. Further papers were concerned primarily with metallurgical analysis, and at least a dozen involved discussions of new methods and apparatus for improving the general spectroscopic analysis of materials.

This annual conference, started in 1933 as a temporary measure to forward the development of applied spectroscopy, has filled such a need that all seats at recent conferences have been reserved in advance. At this eighth conference it was decided that a permanent organization should be formed, to be known as the Society of Applied Spectroscopy. Officers were elected for the ensuing year as follows: *President,* Dr. G. R. Harrison, Massachusetts Institute of Technology; *Vice-President,* Dr. W. F. Meggers, National Bureau of Standards; *Secretary,* Dr. R. A. Wolfe, University of Michigan; *Treasurer,* Dr. T. M. Hess, Dow Chemical Company.

One of the first items of business of the new society was consideration of the desirability of founding a quarterly *Journal of Applied Spectroscopy,* to take the place of the *Proceedings* of the Spectroscopy Conference, hitherto published annually.

George R. Harrison

NATIONAL ROSTER OF SCIENTIFIC AND SPECIALIZED PERSONNEL

The officers of the National Research Council, in response to suggestions from many of the constituent societies of the council, have recently initiated a move for the development of a national roster of scientific personnel. After a series of conferences, it appeared that the roster should be extended to include not only scientists, but other specialized Americans as well. In this connection, the Social Science Research Council, the American Council of Learned Societies and the American Council on Education joined in a request to the Federal Government that such a roster be developed.

In compliance with this request, a new federal project has been established which is called the National Roster of Scientific and Specialized Personnel. This roster is administered jointly by

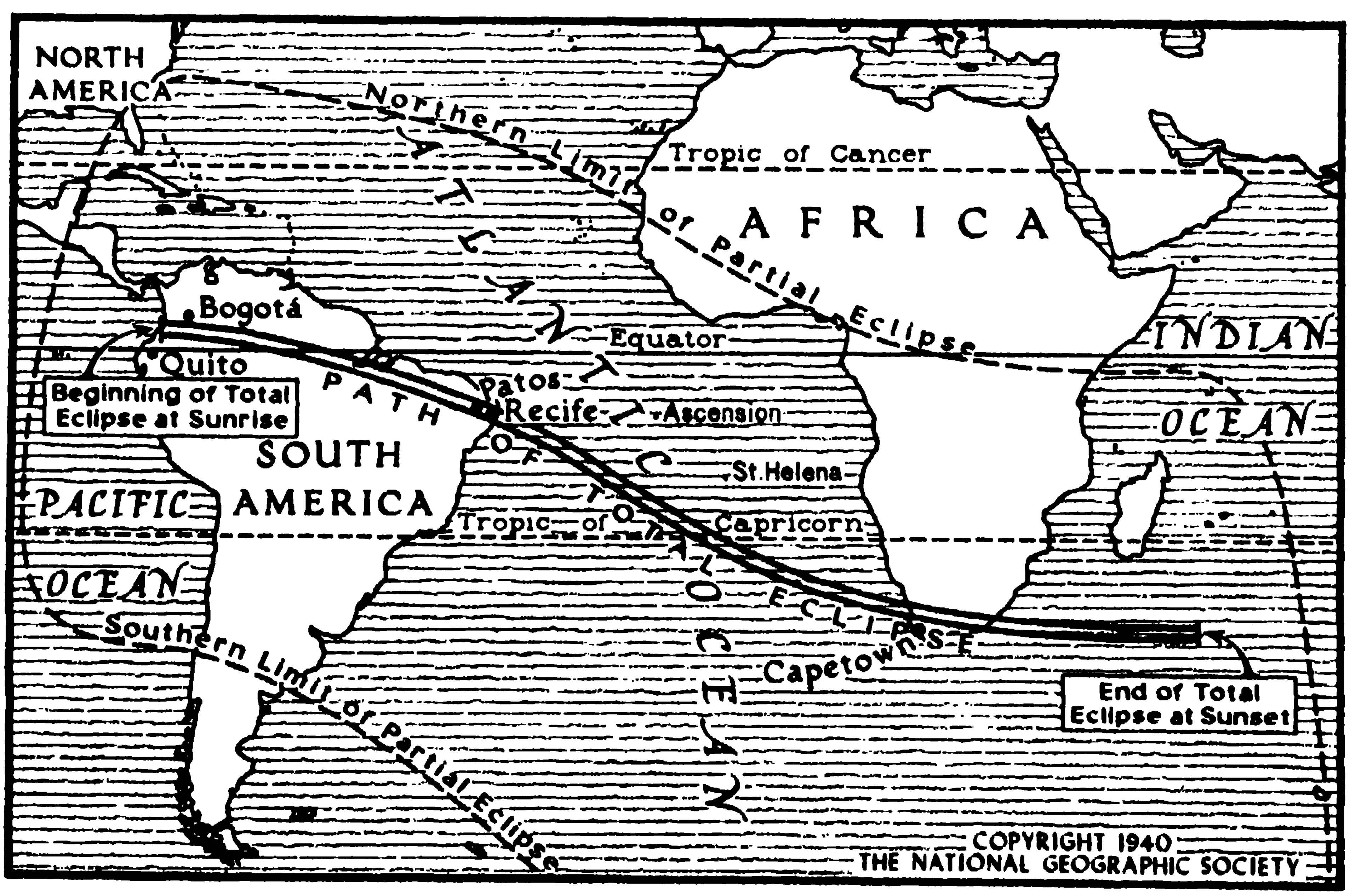
the Civil Service Commission and the National Resources Planning Board. Its executive officer is James C. O'Brien, of the Civil Service Commission, and its director, Leonard Carmichael, president of Tufts College.

The development of the roster, which is now in active production in Washington, has involved the construction of an elaborate questionnaire, to be sent to all scientists and specialized workers in the country. Accompanying this questionnaire, as sent to each individual, is a check list of special proficiencies in his own field. For example, a group of cooperating physicists has developed a list of items of specialized proficiencies in that science which will allow each physicist to designate the field or fields in which he has greatest capacity. The information received from this check list and questionnaire will then be coded in connection with the already existing federal occupational codes. Incidentally, this procedure will extend these codes to the specialized proficiencies of scientists. After the material received from each individual has been properly coded, it will be entered upon punch cards and thus made analytically available for the special demands of governmental and other agencies as they appear in connection with emergency and other placement demands. It is difficult to ascertain the total number of individuals who will be included in this continuing census, but it is almost certain that the figure will reach at least the half-billion mark.

LEONARD CARMICHAEL,
Director

ECLIPSE EXPEDITION OF THE NATIONAL GEOGRAPHIC SOCIETY AND THE NATIONAL BUREAU OF STANDARDS

To observe the total solar eclipse of October 1, the National Geographic Society and the National Bureau of Standards are sending a joint expedition to



MAP SHOWING PATH OF THE TOTAL ECLIPSE OF THE SUN

THE OBSERVATIONS OF THE EXPEDITION WILL BE MADE NEAR THE VILLAGE OF PATOS 200 MILES INLAND FROM THE PORT OF RECIFE (PERNAMBUCO).

eastern Brazil.[1] The party of six specialists which sailed from New York on August 24 for Recife (Pernambuco), Brazil, consists of Dr. Irvine C. Gardner, chief of the Optical Instruments Section of the Bureau, leader of the expedition; Dr. E. O. Hulbert, of the Naval Research Laboratory; Dr. Paul A. McNally, S. J., director of the Observatory of Georgetown College; Dr. Carl C. Kiess, spectroscopist, and Dr. Theodore R. Gilliland, radio research specialist of the National Bureau of Standards; and Richard H. Stewart, staff photographer, National Geographic Society.

[1] At least three other expeditions will make observations: One from the Cruft Laboratory of Harvard University, under the direction of Dr. J. A. Pierce, with headquarters in Queenstown, South Africa, will concentrate upon radio problems. Dr. Charles H. Smiley, of Brown University, leads a small party which will study the zodiacal light from Quixeramobin, Brazil. A group from the Amateur Astronomers Association, in New York, led by Charles A. Federer, Jr., will be stationed at Campina Grande, Brazil.

From Recife the expedition will go inland nearly 200 miles to the village of Patos, which lies five miles south of the center line of the eclipse. The instruments will be set up directly on that line. The neighborhood selected is considered most favorable for carrying out the full program which the expedition has scheduled. It is on an inland plateau where drought conditions usually prevail during September and early October.

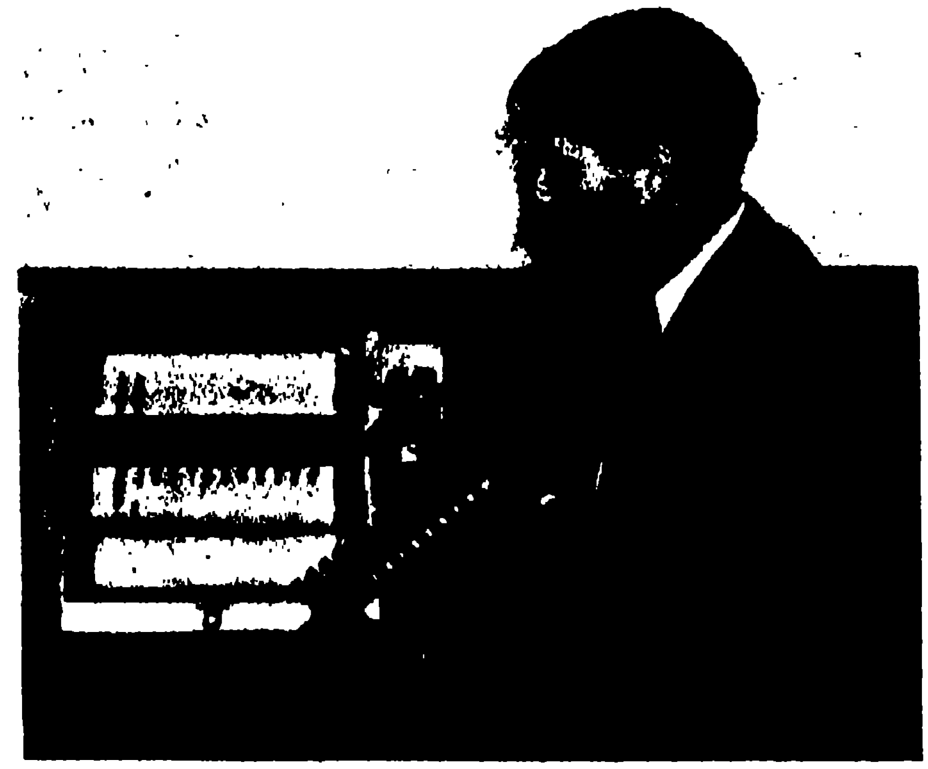
The eclipse conditions themselves are also favorable. The sun will be unusually high (approximately 54°) at the time of totality, and the period of darkness will last for nearly five minutes. To take advantage of these favorable conditions, the National Geographic-Bureau of Standards expedition has designed and built two special spectrographs, each

DR. IRVINE C. GARDNER WITH ONE OF THE SPECIALLY BUILT CAMERAS
THE CAMERA WILL TAKE 12 TO 15 PHOTOGRAPHS OF THE CORONA DURING THE MOON'S 5-MINUTE BLACKOUT OF THE SUN. IT WILL BE OPERATED AUTOMATICALLY WITH OTHER CAMERAS AND INSTRUMENTS BY A PROGRAM CLOCK.

capable of photographing a portion of the sun's spectrum 40 inches long. In addition the expedition designed and built especially for the October 1 eclipse two small, compact telescope-type corona cameras. These will be used to photograph the corona, the delicate halo that extends outward around the sun but which can be seen only during total eclipses. Included in the equipment also will be the large telescope camera designed by Dr. Gardner several years ago with which he has photographed solar eclipses on National Geographic Society expeditions in Russia and on Canton Island in mid-Pacific.

Another important group of equipment, housed in an automobile trailer for ease of transportation, will be used during the eclipse to measure changes in the all-important radio reflecting layers of the upper atmosphere, caused when the eclipse briefly shuts off the sunlight. Other apparatus will include miscellaneous cameras, instrument mountings, clocks, motors and batteries. In all, the expedition will take to Brazil some 15,000 pounds of equipment.

The program to be followed by the expedition will include a complete motion picture record in color of the eclipse from the appearance of the first nick in the sun's disk until the moon has completely passed across its face; photographs of the "flash spectrum" of the sun at the two instants when this phenomenon is visible (just before the beginning and just after the end of totality); repeated photographs of the spectra of the corona during the five minutes of totality; special large photographs of the corona, both in black-and-white and in color, with varying exposures; records of the polarization of the coronal light; the radio reflecting layer measurements; studies of sky brightness, sky radiation, sky spectra and temperature and density changes in the atmosphere during totality. In addition, it is possible that precise observations will be made of the times of apparent contact of the edges of the moon and sun—these in an effort to learn why the moon is usually one or two seconds earlier or later than the computed time for its meetings with the sun.



THE "PROGRAM CLOCK"

WHICH WILL AUTOMATICALLY CONTROL TWO SPECTROGRAPHS AND THREE CORONA CAMERAS. THE APPARATUS WAS DESIGNED BY DR. IRVINE C. GARDNER, WHO IS HOLDING A FRAME ON WHICH ARE MOUNTED SHARP BLADES TO CUT SLOTS IN THE PAPER WHICH RUNS THROUGH THE MACHINE.

The carrying out of this program will be notable because of the surprising degree of simplicity that has been achieved by careful planning, and because almost all the instruments will be "tied together" by a combined electric and vacuum control system which will make the operation of the numerous units almost completely automatic. As a result, this will be one of the few expeditions in history during which the scientists may themselves observe the eclipse phenomena, free from the necessity of strenuous work operating controls during the brief period of darkness.

The expedition will set up its instruments a considerable period in advance of the eclipse and will run through numerous rehearsals. When the program is worked out in complete detail, a roll of paper, somewhat like a player piano roll, will be punched with necessary holes and slots and will be run through the "pro-

ONE OF THE SPECTROSCOPES FOR PHOTOGRAPHING THE SUN'S SPECTRUM
DR. IRVINE C. GARDNER (LEFT), LEADER OF THE EXPEDITION, AND A TECHNICAL ASSISTANT EXAMINE THE FILM MAGAZINE MECHANISM.

gram clock'' at a definite rate of speed. Through the open spaces electrical contacts will be made which, at the proper instants, will open and close shutters, wind films, and apply suction to hold films in the proper planes. A second electrical device and recorder operated by a chronometer will make a complete record of all the operations that have taken place, measuring exposures, for example, to the fraction of a second. This record will be available for the proper development of the films and for the study of brightness from the photographs.

The spectrographs are of unusual design. They are slitless, using concave gratings and no lenses. Made of a shining aluminum alloy, the two instruments, twins in appearance, when set up will look like light cannons trained at the sun. Their tubes are about 15 feet long and they have a focus of approximately 11 feet. Each will project a spectrum 40 inches long on photographic film in a giant magazine which lies below the barrel. This magazine has ingeniously been mounted ''on the bias.'' This permits the 40-inch image to be recorded diagonally across a 9-inch strip of film, and makes necessary a winding of only 12 inches of film between each exposure. In the two spectrographs the sun's spectrum is divided so that one instrument takes care of the light of wave-lengths between 3,000 and 5,000 Angstrom units, and the other, the light between 5,000 and 10,000 Angstrom units.

The gratings used in the spectrographs

have been prepared with extreme care and produce images of unusual brightness. One with 15,000 lines to the inch was prepared by Robert W. Wood, of the Johns Hopkins University. The other, by Henry G. Gale, of the University of Chicago, has 30,000 lines to the inch.

The radio-measuring equipment will not be connected with the electric control system, but will be operated independently. Whereas the spectrographs and cameras will be pointed directly at the sun, the radio apparatus will send its signals vertically into the darkness aimed at its invisible target of electrified gas molecules—the radio reflecting layers—from 30 to 250 miles overhead. The signals, or some of them, will be reflected back and received and recorded in the trailer.

After the eclipse the expedition will move to Campina Grande, a city of approximately 90,000 inhabitants, to carry on the necessary laboratory work in the development and preparation of the photographic films. The party will sail from Recife on its return voyage to the United States on October 14, and expects to reach New York about October 23.

M. K.

VITAMIN DEFICIENCY AND ABNORMAL BONE GROWTH OF THE CHICK[1]

The modern intensive methods of poultry production require that chicks be reared indoors, to protect them from unfavorable weather conditions. Until about 1923 all attempts to do this failed, because chicks are very susceptible to rickets, but after McCollum announced the discovery of vitamin D the agricultural colleges soon developed production methods by which chicks could be grown with no exposure to sunlight, in very limited quarters. On the whole the more recent practices were successful, but a new disease soon appeared which was practically unknown before. The leg bones were shortened and thickened and frequently bent or twisted. In more severe cases the tendon of Achilles would slip out of its normal position and fall to one side of the tibia-tarsal joint. This condition was variously designated as slipped-tendon, hock disease, and more recently as perosis. The appearance of this condition was sporadic and unpredictable, and often resulted in heavy financial losses. The condition was aggravated by including in the ration excessive amounts of calcium phosphate and of other calcium compounds, but was not prevented by supplying only minimal amounts of these mineral compounds.

To digress for a moment, the Missouri College of Agriculture began in 1922 a study of the nutritional requirements of the chick, and attempted to rear them on synthetic diets. Since only five vitamins were known at that time, it is needless to say the attempt was not highly successful, and one of the puzzling abnormalities encountered was the leg deformity later designated as perosis. We considered the possibility at the time that this condition was due to a deficiency of one or more mineral elements, though manganese was the only one that received specific attention. Our observations convinced us that under our experimental conditions this disorder was not due to a deficient supply of any inorganic constituent. Recently this same view was expressed by Wiese, Elvehjem and Hart, who observed that perosis is prevented by rice bran, but is not prevented by rice bran that has been heated to a high temperature. This heat treatment should have no effect on the mineral constituents, but might easily destroy an organic component, such as a vitamin.

In 1936 a very important, and to us surprising, advance in the prevention of

[1] The essential data were presented before the Seventh Annual Meeting of the American Institute of Nutrition, in New Orleans, Louisiana, by A. G. Hogan, L. R. Richardson and Homer Patrick.

this disease was announced by Wilgus, Norris and Heuser, of Cornell University, who showed that under their conditions the deformities were almost entirely eliminated by increasing the amount of manganese in the ration. The minimum amount required was approximately 0.005 per cent. of the food supplied.

After the report of Wilgus, Norris and Heuser appeared then, this is the situation as we saw it. We were unable to prevent perosis by supplying 5 times as much manganese as the Cornell group regarded as sufficient. On the other hand, the Cornell group almost entirely eliminated perosis by merely including a minute amount of manganese in the ration. In our view the only explanation of this discrepancy was that two factors are required to prevent perosis. One is manganese, the other is an unrecognized organic factor, a vitamin. Our synthetic diet had contained an abundance of manganese but was deficient in the vitamin, and the ration of natural foodstuffs employed by the Cornell group was deficient in manganese. Additional support for this view is afforded by the observations of the Cornell workers that occasional cases of perosis developed regardless of the amount of manganese supplied. This indicates that their ration was not only markedly deficient in manganese, but was also mildly deficient in the perosis-preventing vitamin.

The next development in this field is the demonstration that perosis is due to a deficiency of a vitamin. It had been our experience through some 15 years that when liver, either fresh or dried, was added to our synthetic diet, the leg deformities were prevented. An extract of liver is also effective, so the problem was to separate it into two fractions, one of which contains the perosis-preventing factor. The second fraction should not prevent perosis, but it must contain the other vitamins necessary to maintain the chick in a reasonably satisfactory nutritional state. A satisfactory method of preparing the fractions mentioned is first to extract dried liver thoroughly with strong alcohol, at 70° C. This fraction contained the perosis-preventing vitamin, along with various others. The liver residue is then extracted with water, at 70–100° C. This water-soluble fraction does not contain the perosis-preventing vitamin, but it does contain others which are required by the chick. This fraction is a constant constituent of the basal diet used to develop perosis. It is our experience thus far that every chick reared on this ration will be affected; the incidence is 100 per cent. In practice the ration is vastly improved for experimental use by adding it to some of the other vitamins, which are now available in pure crystalline form. If the alcohol soluble fraction of the liver extract is also included in this ration the rate of growth is rapid, and no abnormalities develop. According to our hypothesis the protective action of this fraction is due to the presence of a previously unrecognized vitamin, designated for convenience as vitamin B_p.

When a new vitamin is announced we immediately ask what significance may it have, but as yet we have no information on the requirement for this vitamin by other animals. Our first thought is, since it is concerned with the bone development and conformation of the chick, that it may also be concerned with the structural development of other animals and of man himself. At present, though, one can only speculate.

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PROBLEMS OF NEBULAR RESEARCH

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THE OBSERVABLE REGION OF SPACE

THE history of astronomy is a history of receding horizons. The explorations of space have swept outward in successive waves—through the system of the planets, through the stellar system and, recently, into the realm of the nebulae. A large sample of the universe is now available for study, and the sample may be fair.

The general picture of the Observable Region is somewhat as follows:

The earth we inhabit is a member of the solar system. The sun with its family of planets seems isolated in space but the sun is merely a star—one of the millions which populate our particular region of the universe. The stars are scattered about at enormous intervals but on a still greater scale they are found to form a definite system, again isolated in space. On the grand scale we may picture the stellar system drifting through the universe as a swarm of bees drifts through the air.

From our position somewhere within the system, we look out through the swarm of stars, past the borders, into the universe beyond. It is empty for the most part—vast stretches of empty space. But here and there, at immense intervals, we find other stellar systems, comparable with our own. They are so distant that in general we do not see the individual stars. They appear as faint patches of light, and hence are called nebulae, *i.e.*, clouds.

The nebulae are great beacons, scattered through the depths of space. We see a few that appear large and bright. These are the nearer nebulae. Then we find them smaller and fainter in constantly increasing numbers, and we know we are reaching out into space farther and ever farther until, with the faintest nebulae that can be detected with the greatest telescopes, we have reached the frontiers of the known universe. This last horizon defines the Observable Region—the region of space which can be explored with existing telescopes. It is a vast sphere, some 1,000 million light years in diameter, throughout which are scattered 100 million nebulae.

The question immediately arises as to whether the nebulae form an isolated super-system, analogous to the system of the stars but on a still grander scale. Actually, we find the nebulae scattered singly, in groups and occasionally in great clusters but, when very large volumes of space are considered, the tendency to cluster averages out, and, to the very limits of our telescopes, the distribution is approximately uniform. If the Observable Region is divided into 100, 1,000 or even 10,000 equal parts, the

nebular contents of the various fractions are very closely similar. There is no evidence of a thinning out, no trace of a physical boundary. The realm of the nebulae, we must conclude, stretches on and on, far beyond the known frontiers.

Observations give not the slightest hint of a super-system of nebulae. Hence, for purposes of speculation, we may invoke the principle of the Uniformity of Nature and suppose that any other equal portion of the universe, chosen at random, will exhibit much the same general characteristics as the region we can explore with our telescopes. As a working hypothesis, serviceable until it leads to contradictions, we may venture the assumption that the realm of the nebulae *is* the universe—that the Observable Region is a fair sample, and that the nature of the universe may be inferred from the observed characteristics of the sample.

The Nature of the Problems

Investigations in these new fields follow two lines of attack. The individual nebulae may be studied as stellar systems, or the Observable Region may be studied as a unit. The ultimate problems, as usual, are formulated in evolutional terms. On the one hand, we wish to describe the individual nebulae as particular stages in the life history of stellar systems. On the other hand, we wish to describe the Observable Region as a local aspect of a particular stage in the life history of the physical universe. The solutions of these problems are beyond our present powers but the formulations serve as an ordered framework into which all the limited, detailed investigations find their places.

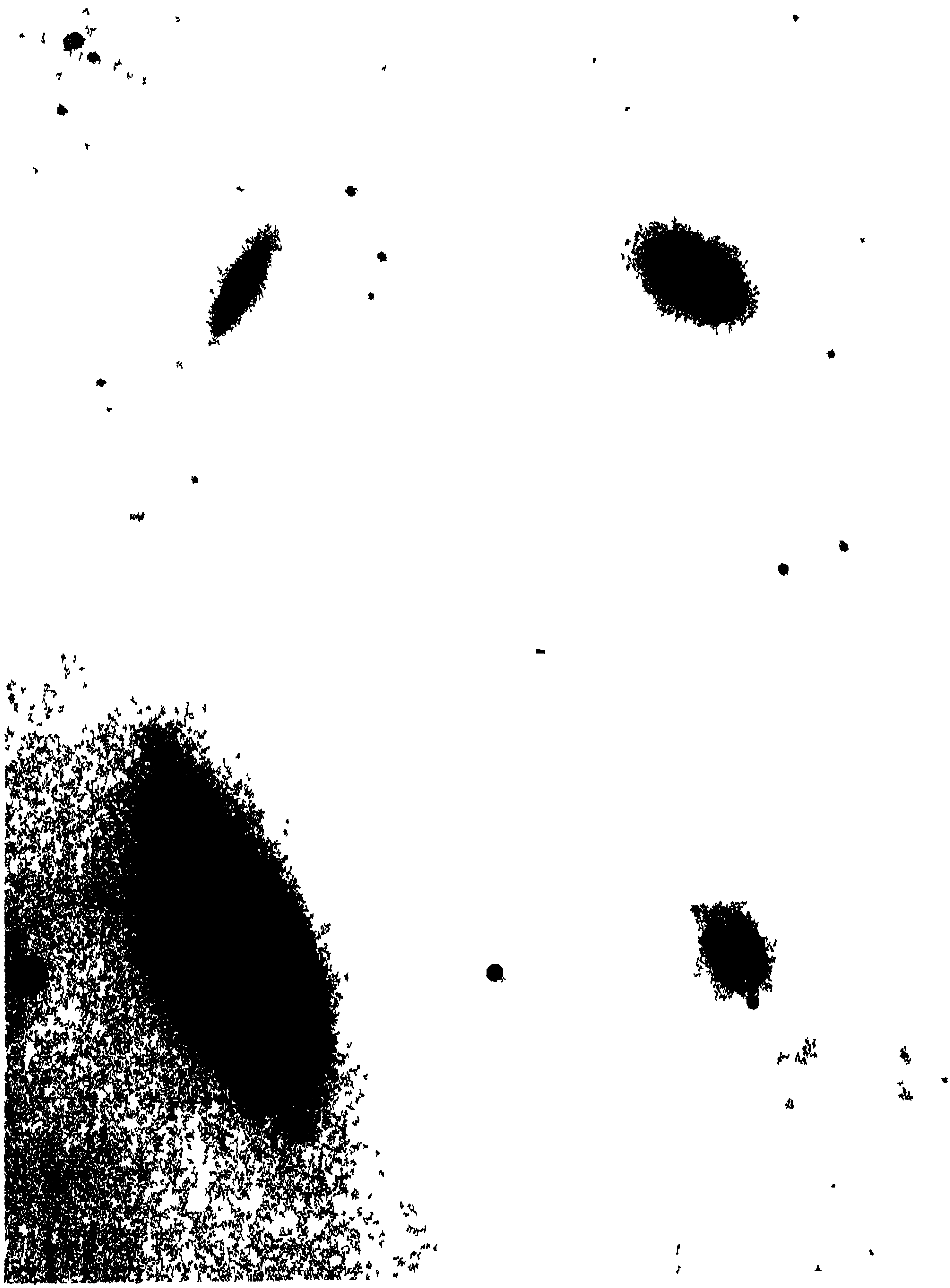
Progress may be summarized as follows. An approximate scale of distance has been established throughout the Observable Region. Dynamical information is slowly accumulating but is still fragmentary. The time scale is wholly speculative.

The Distance Scale

The distance scale permits a static description of the Observable Region and its contents, and the preliminary sketch has been completed. We know, in a general way, the structural forms of nebulae, the brighter elements of their contents, their dimensions and their distribution throughout the Observable Region. This preliminary phase of the subject is probably approaching its final form. Further investigations may be expected to fill in details and improve the numerical accuracy without seriously changing the general outlines.

The distance scale followed the identification, in the nearer nebulae, of objects that are well known in our own stellar system. Novae, for instance, clusters, diffuse nebulosities, blue supergiants and, in particular, Cepheid variables were recognized, all in their proper order of relative luminosities. Since their intrinsic luminosities are known, their apparent faintness indicates their distances wherever they are found. For instance, some 40 Cepheids in the great spiral in Andromeda are known to average about 3,000 times brighter than the sun but they appear about 150,000 times fainter than the faintest star that can be seen with the naked eye. A simple calculation indicates that the spiral must lie at a distance of nearly a million light years, and other types of objects found in the spiral confirm the order of this result.

A few reliable distances, determined in this manner, have served to calibrate other methods, less accurate but extending over greater ranges. Eventually, it was found that the nebulae are all of the same general order of total luminosity. They average about 80 million suns, and the majority lie between the narrow limits from one half to twice the



TRANSITION TYPES

Upper left: LENTICULAR SYSTEM, NGC 4350, CLASSED AS E7, THE FLATTEST OF THE ELLIPTICAL NEBULAE. *Upper right*: NGC 4150, THE EARLIEST OF THE TRANSITION TYPE, S0. A CENTRAL LENS IS VAGUELY DIFFERENTIATED FROM THE MAIN BODY OF THE NEBULA. *Lower*: A LONG AND A SHORT EXPOSURE OF NGC 4526, A MORE ADVANCED FORM OF THE TRANSITION TYPE. THE CENTRAL LENS IS WELL DIFFERENTIATED, AND, WITHIN THE LENS, IS A RING OF FINELY DIVIDED, DARK MATERIAL, PRESUMABLY DUST. (NEGATIVE PRINT.)

average value. Thus the apparent faintness of the nebulae themselves forms a sound statistical criterion of distance out to the very limits of the telescopes. For instance, the faintest nebulae identified with the 100-inch reflector lie at an average distance of the order of 500 million light years. Some of these ghostly images at the threshold of identification on the best plates, are doubtless dwarf systems, much nearer than the average, and some are giants at still greater distances. We can not select these individual objects—we can only state the statistical average. However, it seems likely that no nebula has yet been recognized as such, which lies at a distance greater than 1,000 million light years.

Another criterion of distance is found in the red shifts in the spectra of nebulae. The lines in these spectra are, in general, slightly displaced to the red or to the violet, according to the random velocities of the nebulae as they drift through space. But superposed on this familiar pattern is a systematic displacement to the red which is proportional to the distance. The interpretation of the phenomenon is quite speculative but, regardless of their origin, the red shifts indicate the distances of the individual nebulae, subject only to the errors introduced by the relatively small peculiar motions.

The Sequence of Classification

The characteristic feature of the nebulae is rotational symmetry around dominating central nuclei. About 2.5 per cent. do not show this feature, and are called Irregular. The regular nebulae fall naturally into a continuous sequence of structural forms ranging from compact globular bodies to the widely open spirals. This sequence of classification seems to be fundamental because many features, in addition to structural forms, vary symmetrically throughout the range—stellar contents, for instance, spectral types and colors. The sequence may represent the evolution of stellar systems although this suggestion is highly speculative. We actually observe that the contents of nebulae are correlated with structural forms. We conclude that contents may determine form or that both may be determined by a third factor. In a search for a third factor, we are able to eliminate the quantity of luminous material, and, presumably, the mass. About the only plausible factor left is time, or evolution. Let us examine the sequence with this possibility in mind.

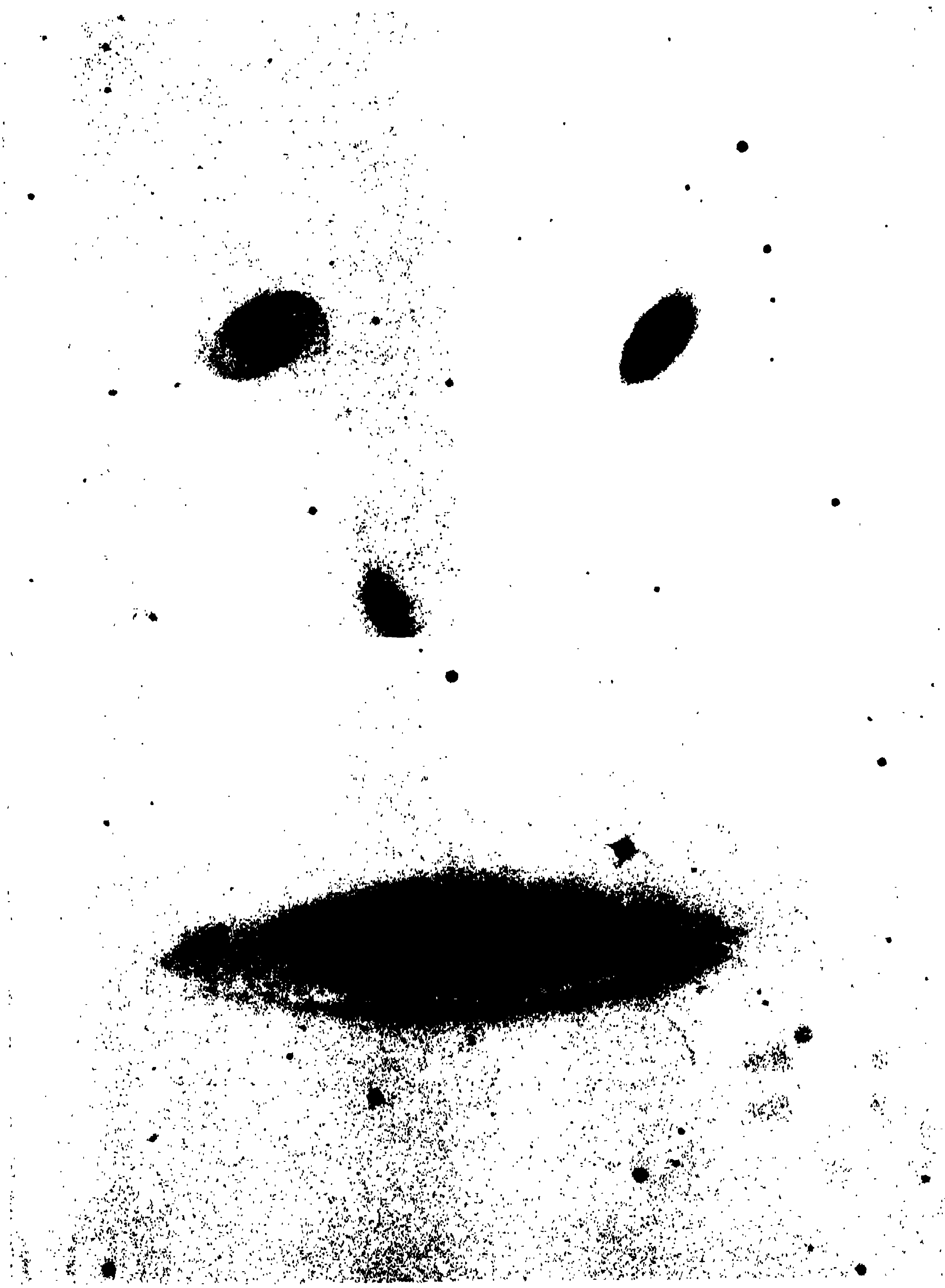
The nebulae fall into two groups, elliptical nebulae and spirals, with a transition stage between them. The members of each group fall into progressive sequence which fit into one another to form the sequence of classification. However, the spirals fall into two parallel series representing the normal and the barred spirals respectively. Thus the complete sequence is bifurcated like a tuning fork.

Elliptical Nebulae

The handle is formed by the elliptical nebulae ranging from globular masses, to flattened, lenticular bodies with a ratio of axes about 3 to 1. These nebulae are very homogeneous. They are not resolved and show no structure other than a steady fading of the luminosity from the center outward to undefined boundaries.

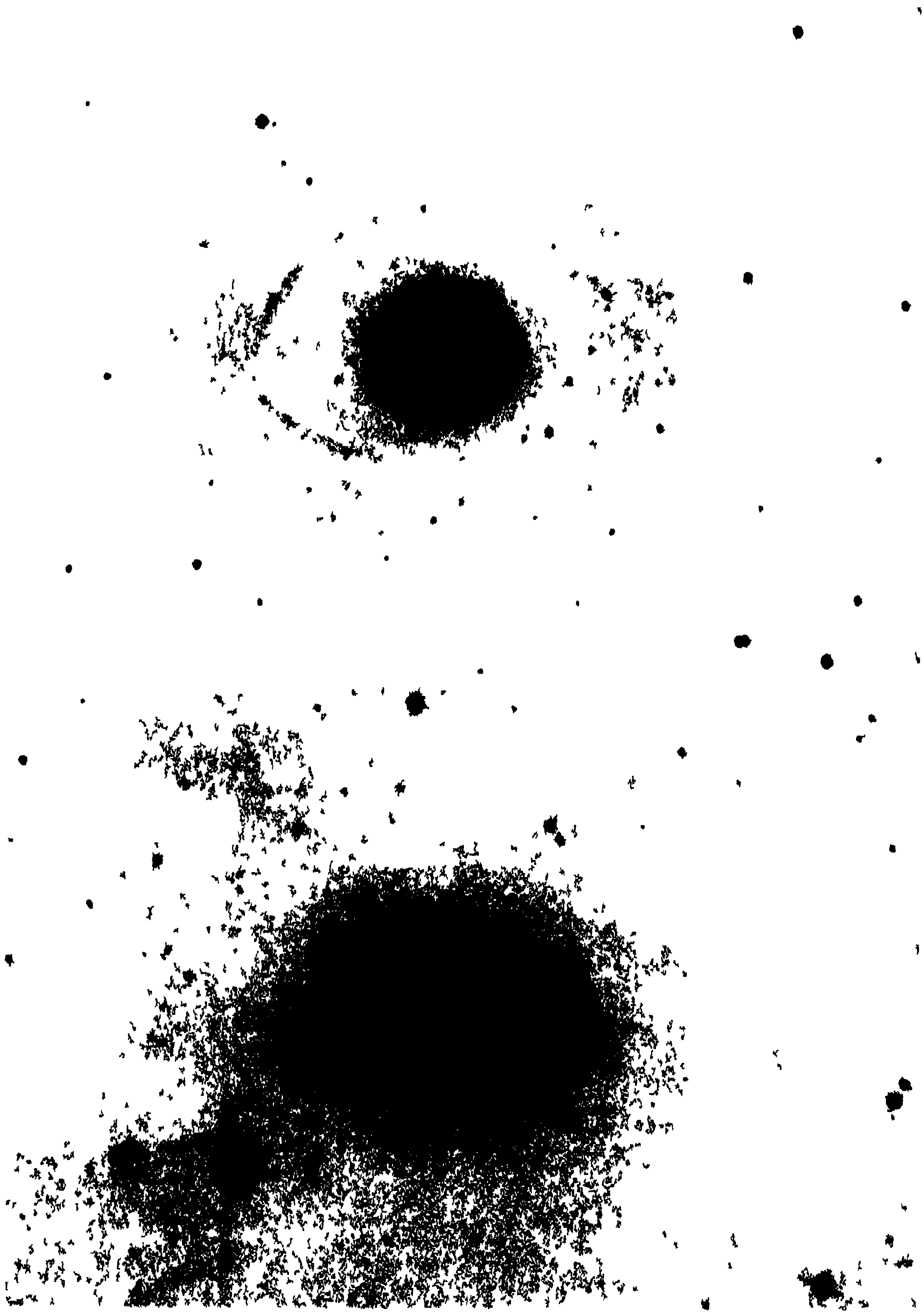
Transition Stage

The transitional stage follows the flat end of the elliptical series. The first evidence of internal structure is the differentiation of a bright central lens with a diameter about one third that of the main body of the nebula. Thereafter, circular patterns of obscuration—lanes of dark, finely divided material, silhouetted against the luminous back-



EARLY TYPE SPIRALS

Upper left: NGC 4440, A BARRED SPIRAL, SBA. *Upper right:* NGC 4324, A NORMAL SPIRAL, SA, IN WHICH A RING STRUCTURE HAS DEVELOPED OUTSIDE THE LENS, AND HAS PARTIALLY DISINTEGRATED. *Lower:* NGC 3623, SA, IN WHICH A SPIRAL PATTERN HAS DEVELOPED WITHIN THE MAIN BODY. (NEGATIVE PRINT.)



INTERMEDIATE TYPE SPIRALS

Left NGC 488, A NORMAL SPIRAL *Right* NGC 1398, A BARRED SPIRAL THE SPIRAL PATTERNS ARE WELL DEVELOPED, BUT THE NUCLEAR REGIONS REMAIN UNRESOLVED (NEGATIVE PRINT)

ground—appear either within the lens or in the faint, outer regions.

Normal Spirals

Along the sequence of normal spirals, the circular patterns eventually disintegrate into spiral structure—first fragmentary, closely coiled arcs, and then longer, more open arms. Fairly early in the series, arms of luminous materials appear, in addition to the absorption lanes, and, as the sequence progresses, these arms dominate the structural patterns. In the last stages, practically the whole of the luminous material, right into the nucleus, is concentrated into widely open arms. The nucleus, in general, remains as a semistellar condensation, somewhat resembling the largest of the globular clusters in brightness and in spectral type.

About the middle of the sequence, the arms begin to break up into condensations representing individual stars and groups of stars. The process generally begins in the outer regions and works inward, until, in the end, it reaches the nuclear region itself. The stars that can be detected are blue supergiants, and their presence is one of the main distinctions between the contents of spirals and the contents of elliptical nebulae. The latter systems lack supergiants. In fact, the data suggest that the upper limit of stellar luminosity increases steadily from globular nebulae to open spirals, and emerges above the observable threshold somewhere in the middle of the sequence of spirals.

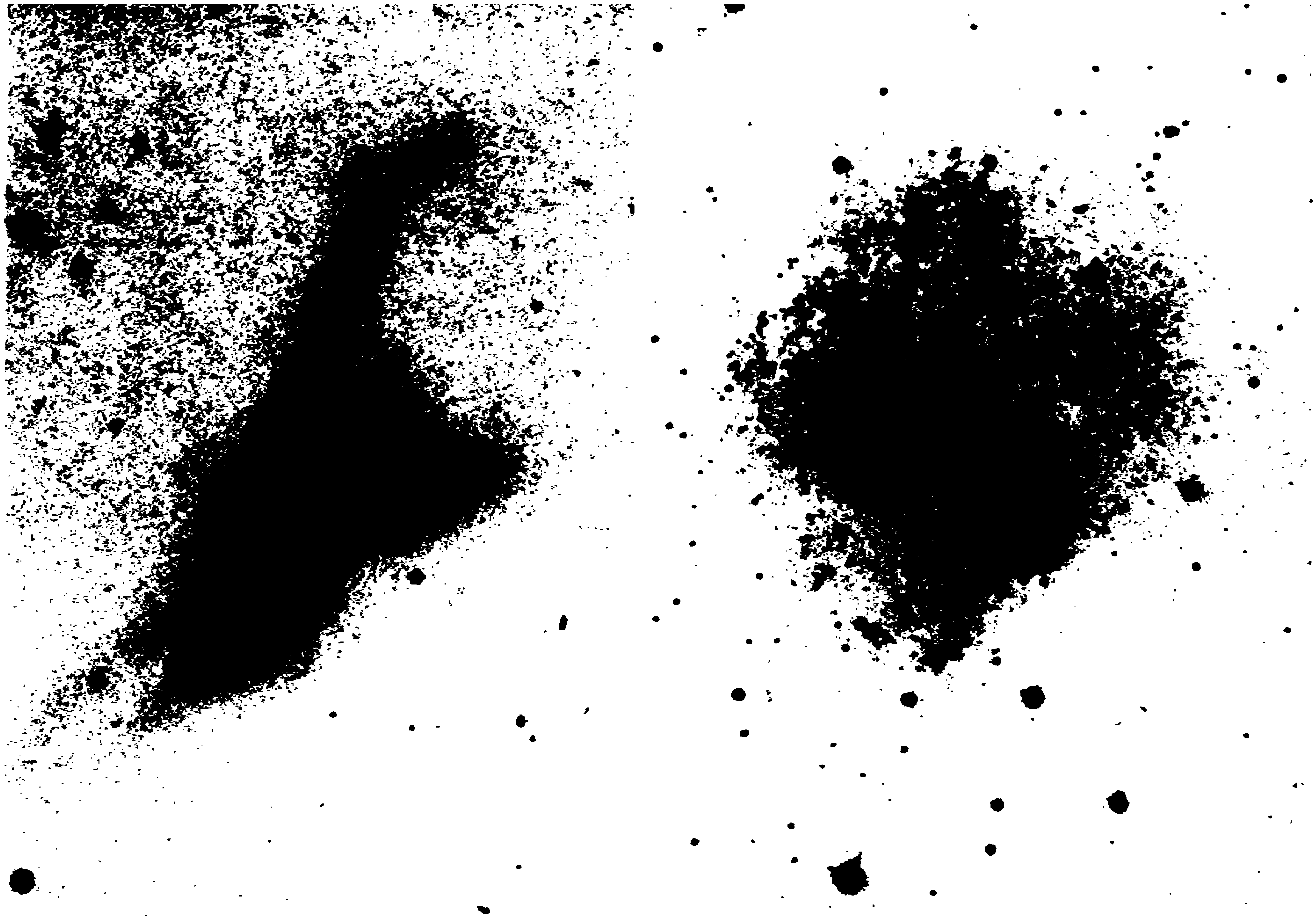
Barred Spirals

The sequence of barred spirals branches off from the normal sequence in the early section of the transition stage. A bright diameter appears across the lens and develops into a definite bar which stops abruptly at the rim of the lens. Furthermore, the entire rim of the lens condenses into a ring so that the structural pattern resembles the Greek letter capital Theta. Then, in general, the ring appears to break from the bar at two points—just above the bar at one end, and just below, at the other end. The further behavior is not entirely clear but frequently the broken ends of the ring seem to drift outward and to develop into spiral pattern. The prevailing pattern is that of two arms springing abruptly from either end of a diametrical bar, and winding outward along spiral paths. In the last stages, the arms are almost completely unwound, and approximate straight lines. In other respects, the progress along the sequence closely parallels that along the normal sequence.

Irregular Nebulae

As an appendix to the sequence, some mention should be made of the irregular nebulae. These fall into two roughly equal groups. One group, represented by NGC 520 and 5128, consists of chaotic masses of unresolved nebulosity and dark material. Little is known concerning these remarkable objects other than the facts that their luminosities and their spectral types are closely comparable with those of regular nebulae. Presumably, they consist of stars and dust and, occasionally, gas but, like the early type nebulae, they lack supergiant stars.

The second group of irregular nebulae contains systems resembling the Magellanic Clouds. They are highly resolved but present no nuclei nor any evidence of rotational symmetry. The luminosities range from those of normal nebulae down to dwarf systems scarcely brighter than the globular clusters. These dwarf irregulars raise an interesting problem, and one of considerable importance in cosmological theory. We wish to know whether there is a lower limit to the size of independent stellar systems or whether they finally merge into smaller



IRREGULAR NEBULAE

Left: NGC 520, A CHAOTIC TYPE. *Right:* BAADE'S SYSTEM IN SEXTANS (R.A. $10^h\ 8.1^m$; DEC. $-4°24'$, 1940), A MAGELLANIC CLOUD TYPE. BAADE REPORTS THAT THE SEXTANS SYSTEM IS A FAINT DWARF ($M_{pg} = -10$), AT A DISTANCE OF THE ORDER OF 1.1 MILLION LIGHT YEARS. (NEGATIVE PRINT.)

organizations such as mere clusters of stars?

The specific problem, stated in technical terms, is the determination of the faint end of the luminosity function (*i.e.*, the curve representing the relative frequencies of nebulae of different intrinsic luminosities). The curve is assumed to resemble a normal error curve because the bright end, extending over the peak, is known to approximate that form. However, the faint end is extremely difficult to determine with precision, and we merely guess that the two ends are symmetrical—that giants and dwarfs are equally numerous. The uncertainty is not important for statistical investigations—it is sufficient to know that the curve has a peak, that a most frequent luminosity does exist.

The difficulty arises from the fact that dwarfs, because they are intrinsically faint, can be detected only in our immediate neighborhood—that is, through a small volume of space. The giants, on the other hand, can be observed out to great distances, and hence through a very large volume of space. For instance, giants which are 100 times brighter than dwarfs should be 1000 times more numerous among the nebulae which are brighter than a given limit of apparent faintness. Since our detailed information is restricted to fairly bright limits, the giants are far better known than the dwarfs.

Our nearest neighbors in space are some 12 nebulae which, together with our own system, from a loose cluster, more or less isolated in the general field. Within this cluster, known as the Local Group, there are 5 dwarfs, of which 4 are irregular nebulae of the Magellanic Cloud type. This large percentage of dwarfs is disturbing, and the question arises as to whether or not there are corresponding numbers in the general field which we have missed because they are so faint.

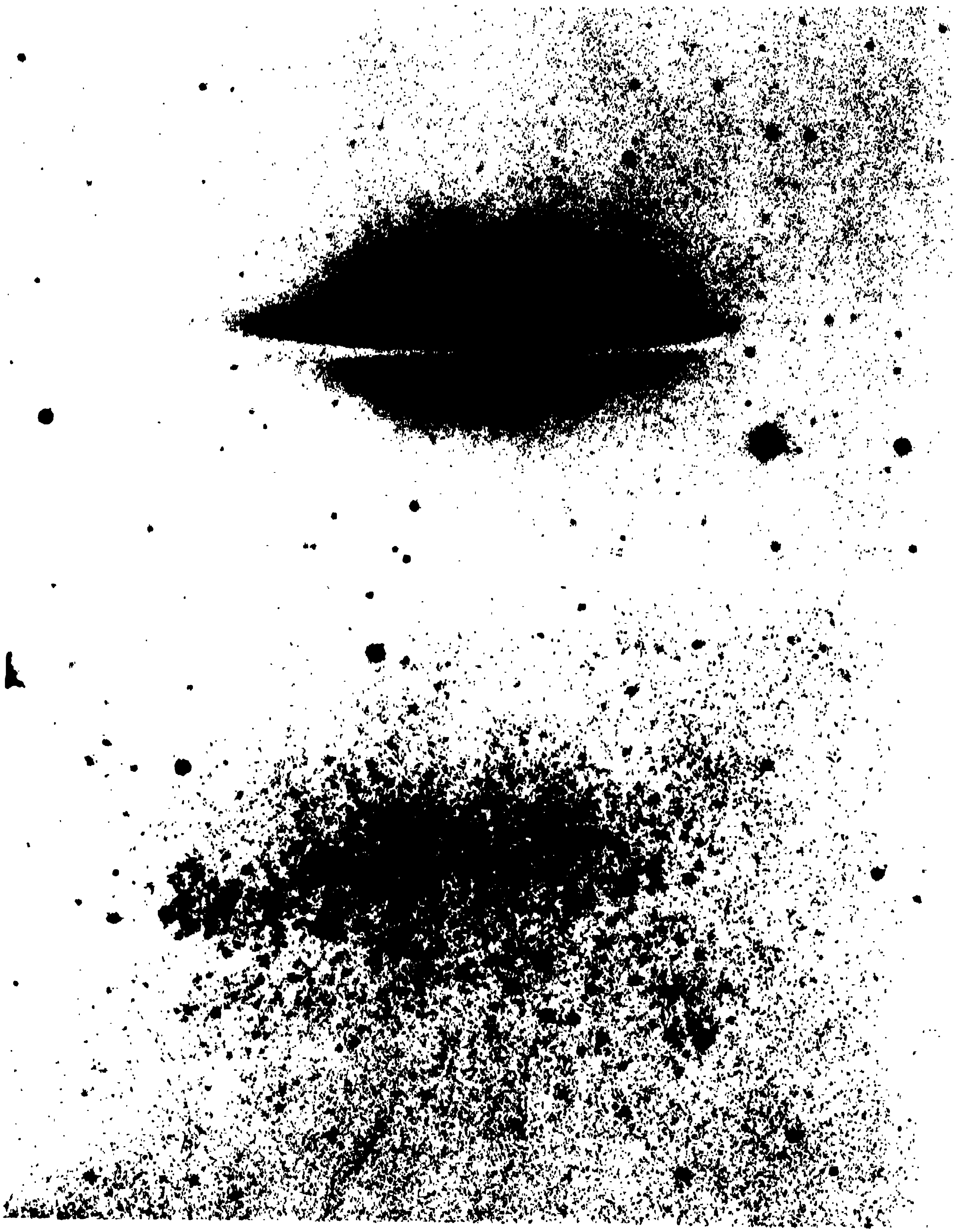
My colleague, Dr. Baade, is investigating this question by studying with the 100-inch reflector a list of possible dwarfs assembled by Dr. Zwicky from surveys with the 18-inch Schmidt reflector on Palomar. Samples of the results are furnished by two uncatalogued systems, in Sextans and in Leo, which are intrinsically the faintest systems known. One, the system in Leo, is no brighter than Omega Centauri, the brightest of the globular clusters.

Some General Features of the Sequence

The 1,000 brightest nebulae in the northern sky have all been photographed with large reflectors, and, from these data, the quantitative aspects of the sequence of classification are fairly well known. About $\frac{1}{5}$ are elliptical nebulae and $\frac{4}{5}$ are transitional objects or spirals. Of the spirals, about $\frac{1}{5}$ fall into the barred sequence and $\frac{4}{5}$ into the normal sequence. Only 23 are classed as irregular. The most frequent type is the late type, normal spiral.

At any stage in the sequence, the nebulae are closely similar. They may be large and bright or small and faint but they are built on the same pattern. Thus it is possible to establish and compare standard models at various stages. It is then found that, for nebulae of a given total luminosity, the diameters increase steadily from the globular bodies to the open spirals—the sequence is an expanding sequence, with average diameters ranging from perhaps 1,200 light years to 12,000. This systematic variation, superposed on the inherent scatter in size, must be fully taken into account in any attempt to use the apparent diameters as criteria of distances.

When the sequence is considered from the evolutional point of view, the central problems are (a) the origin and development of spiral arms, and (b) the interpretation of the bars in barred spirals.



GIANT AND DWARF

Upper: NGC 4594, THE BRIGHTEST KNOWN GIANT, IS ESTIMATED TO BE ABOUT 2300 MILLION TIMES BRIGHTER THAN THE SUN. *Lower:* BAADE'S SYSTEM IN LEO (R.A. 9^h 55.9^m; DEC. $+31°2'$, 1940), THE FAINTEST KNOWN DWARF. BAADE ESTIMATES THIS IRREGULAR NEBULA TO BE ABOUT HALF A MILLION TIMES BRIGHTER THAN THE SUN ($M_{pg} = -8.7$). (NEGATIVE PRINT.)

These problems will be mentioned presently, in connection with dynamical investigations. At the moment, attention may be called to one aspect of the subject. It was once believed that spiral arms were normally ejected from two opposite points on the rims of the central lenses. However, accumulating data raise serious doubts as to the validity of this assumption. Theories of the origin and development must now take into account the new empirical results. The earliest evidence of spiral structure is furnished by absorption lanes, evidently representing finely divided, dark material. Moreover, the spiral patterns seem to follow a transitional stage of circular patterns, and both seem to form by the differentiation of material already in place rather than by the ejection of new material into regions previously unoccupied. The significance of the data is not clear but they suggest that viscosity may play an important role in the interpretation of structure.

Supernovae

The discussion of the contents of nebulae will be restricted to one type of object. The most spectacular phenomena observed within the nebulae are the tremendous outbursts known as supernovae. It had long been known that, in addition to the normal novae, so frequently recorded in the galactic system and its nearer neighbors, novae like stars of a totally different order of luminosity were occasionally observed in the nebulae. About 1935, Zwicky initiated an intensive study of these "supernovae," using the 18-inch Schmidt reflector on Palomar, and, later, Baade and Minkowski took up various phases of the problem with the large reflectors on Mt. Wilson. These investigations have led to results of extraordinary significance.

The supernovae represent a definite class of objects quite distinct from normal novae, and averaging nearly 1000 times brighter. No clear evidence of intermediate objects has yet been found. The supernovae at maxima are comparable with the integrated light of the stellar system in which they appear ($M_{pg} = -14.2$, or 80 million suns). Although they are extremely rare—they occur at the rate of one per nebula per several (3 to 6) centuries—the number of nebulae in which they can be observed is so great that several supernovae are generally visible within the Observable Region at any given time. Only those outbursts which occur within our immediate neighborhood, say within 6 or 8 million light years, can be studied to advantage with spectrographs.

The first half dozen supernovae whose spectra were studied in detail proved to be closely similar. The spectra consisted of broad, overlapping emission bands in the red and blue, with very faint, structureless, continuous spectra in the ultraviolet. The bands were well developed even before maximum luminosity, and, in each case, the positions and relative intensities changed as time went on, according to a definite pattern. No single detail has been identified in these spectra, hence, while the general appearance and behavior is well established, the interpretation is wholly unknown.

Just about the time the problem was supposed to be fully formulated, supernovae of another type (now called type II) were recognized by Minkowski, which differ from those described above (now called Type I) in their spectra, and, according to Baade, their light curves and maximum luminosities. Type II supernovae appear to be slightly fainter than Type I, and they present shoulders in the light curves which are absent in the brighter class. The spectra in Type II are continuous through maximum luminosity but, between one and three weeks after maximum, they

SUPERNOVA IN NGC 4725

THE NEBULA IS IN THE LARGE URSA MAJOR GROUP AT A DISTANCE OF THE ORDER OF 5.5 MILLION LIGHT YEARS. THE SUPERNOVA—THE BRIGHT STAR MARKED BY AN ARROW—IS ABOUT 40 MILLION TIMES BRIGHTER THAN THE SUN. THE PLATE WAS MADE BY BAADE WITH THE 100-INCH, ON MAY 10, 1940, FIVE DAYS AFTER THE SUPERNOVA HAD BEEN DISCOVERED BY JOHNSON AT PALOMAR.

develop broad emission bands which, in general, resemble those of normal novae in the transition stage. Hydrogen bands appear to be definitely present, although relatively faint, while the forbidden lines are very faint or missing.

Type II supernovae, it is believed, may contribute essential clues to the interpretation of Type I. The two groups, together, should furnish significant information concerning the behavior of matter under extreme conditions. For supernovae represent explosions on the most tremendous scale known in the universe. Although we observe the explosions millions of years after they actually occur, the reports of the events are carried so faithfully by the light waves that we have no doubts they will eventually be read with confidence.

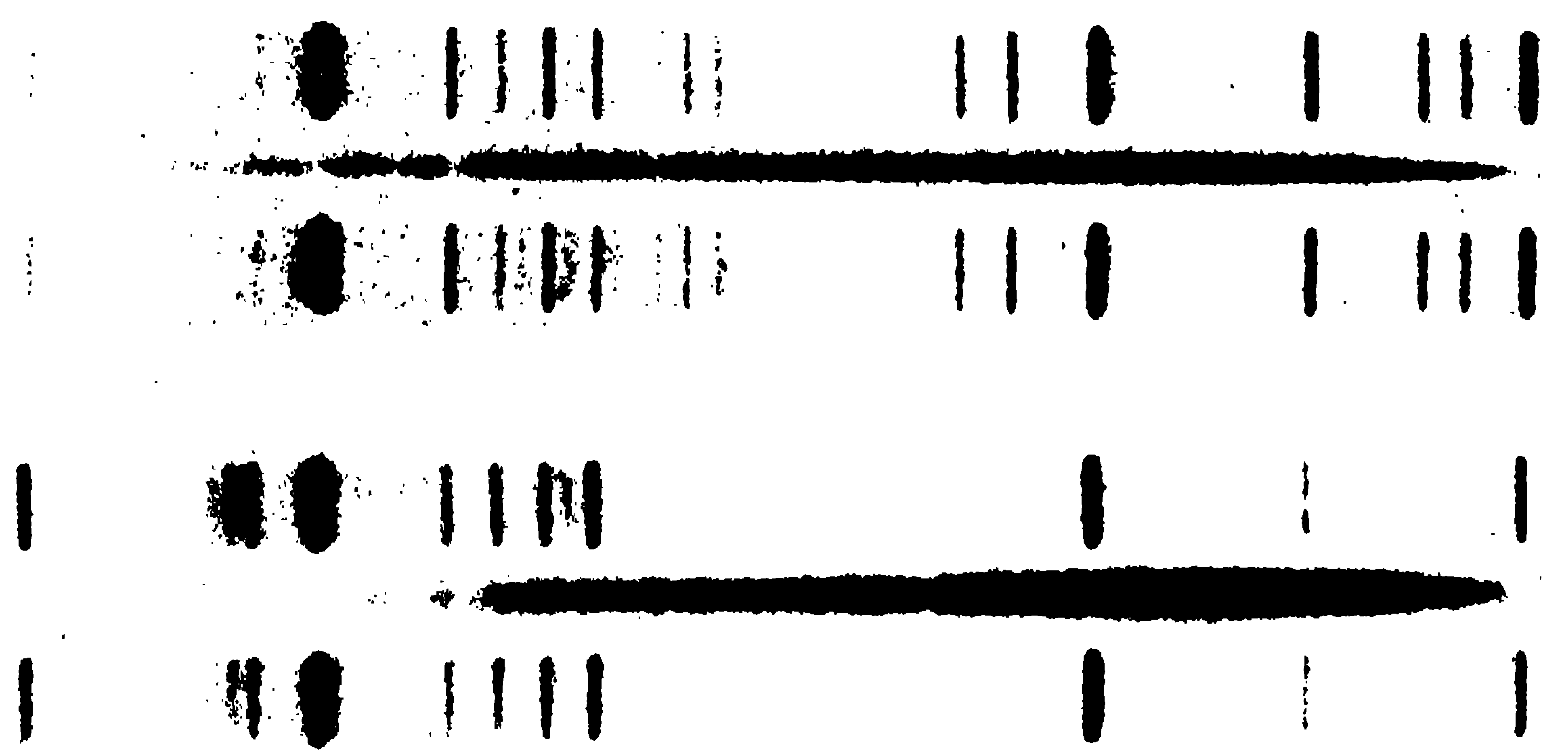
Supernovae have doubtless occurred from time to time within the galactic system but certainly none has been observed since the spectrograph has been in general use. Two historical cases, however, are presumed to represent supernovae. One is Tycho Brahe's star of 1572 which could be seen in broad daylight. The position is known with unusual accuracy, but exhaustive searches have failed to find the remnants of the explosion. The second case is a nova of 1054 which blazed out as bright as Jupiter, and which is recorded in the annals of both the Chinese and the Japanese. The position is only roughly recorded but it is in the vicinity of the Crab Nebula (NGC 1952). The latter object is a mass of nebulosity which is known to be expanding at such a rate that if the rate has remained constant the expansion must have started just about the time the nova was observed. For this reason, the Crab Nebula is assumed to be the remnants of the outburst, which from the apparent brightness and the known distance (order of 5000 light years), was evidently a supernova.

Dynamics of Nebulae

The question of spiral structure introduces the subject of dynamics. The development of this subject requires a knowledge of motions, and, because of the great distances, such data are restricted to radial velocities. Moreover, the nebulae are faint objects and, consequently, the great majority of the available spectra are on very small scales—perhaps 300 to 500 angstroms per mm at $H\gamma$. Nearly 400 such spectra have been assembled at Flagstaff, Mt. Hamilton and Mt. Wilson—about 300 at Mt. Wilson alone. These data furnish a preliminary survey of the field and make it possible to formulate the significant problems that can be investigated. However, the scales are so small that only the most conspicuous phenomena have been isolated and studied to advantage.

For individual nebulae, it has been found that spectral types of the nuclear regions vary systematically through the sequence of classification, ranging from about G5 for the globular nebulae to about F0 for the late type spirals, and that emission lines, indicating the presence of gas, and of stars sufficiently hot to excite the gas (*i.e.*, blue-giants and supergiants) become increasingly prominent as the sequence progresses.

Dynamical data are fragmentary. Motions within nebulae may be either random or systematic. Random motions, in limited regions, should widen the spectral lines, and the velocity dispersions, indicated by the line contours, should furnish important information concerning the distribution of mass within the nebulae. The lines are so narrow that the contours can not be studied on the small scale spectra now available. However, spectrographs and plates have been developing so rapidly that it is now possible to use moderate scales—say 70 Å per mm at $H\gamma$—and to extend the investigations into the red with gratings. These technical achieve-



TYPES OF NUCLEAR SPECTRA

Upper: NGC 598, SC, SPECTRAL TYPE FO. *Lower:* NGC 3384, SBO, SPECTRAL TYPE G5. THE SPECTRA WERE RECORDED WITH A DISPERSION OF 175 A/MM AT Hγ. RED IS AT THE RIGHT; COMPARISONS ARE HELIUM, HYDROGEN AND NEON. NEARLY ALL THE NEBULAE HITHERTO OBSERVED FALL WITHIN THE RANGE OF SPECTRAL TYPES HERE ILLUSTRATED.

ments are expected to open a new chapter in nebular research.

Rotations of Nebulae

Systematic internal motions furnish rotational patterns, and, in spite of the difficulties, such data have already been derived for a half-dozen favorable cases. Four early type nebulae have been studied at Mt. Wilson, and two later type spirals, at Mt. Hamilton. The main bodies of these nebulae rotate like solid bodies—the velocities of rotation increase directly with distance from the nucleus—again suggesting the important role played by viscosity. It seems unlikely that such a phenomenon can extend indefinitely outward but evidence that rotational velocities begin to decrease beyond certain distances, has been fragmentary. However, at the meeting of the American Association at Seattle in June, Dr. Mayall presented a very important study of the pattern for the late type spiral Messier 33, which clarifies the situation to a marked degree. The velocity of rotation increases almost linearly out to the limits of the main body but beyond, in the extremely faint extensions, it decreases steadily until eventually it is barely perceptible. The data furnish the first clear suggestion of solid body rotation in the main body, and planetary rotation in the extreme outer regions.

Some of the significance of these new results arises from the fact that our own system is presumably a late type spiral, similar to M33. Hitherto, there has been an apparent contradiction between the current, very plausible conception of differential galactic rotation, and the observed solid body rotation in the main bodies of the other nebulae. Dr. Mayall supplies a possible solution to the difficulty—it is only necessary to place the sun outside the main body of our stellar system—a plausible interpretation because we already know that the sun is at a great distance from the center of the system.

Future investigations along these lines will endeavor to establish normal rotational patterns at successive stages along the system of classification, and to extend them, where possible, to the extreme outer regions of the nebulae.

Meanwhile, there are some curiously

baffling rotational problems, which may be solved in the near future. We do not yet know the direction of rotation—whether the spirals trail their arms or push the arms ahead. We do not know whether the points of ejection, if they actually exist, rotate with the nebulae or remain fixed in space, and, in the barred spirals, the same question applies to the bars. Until these apparently simple problems are solved, discussion of the origin and development of spiral structure will necessarily remain in the realm of speculation.

The first problem is especially baffling. Rotations are derived from radial velocities along the major axes of tilted nebulae. An object seen edge-on is the most favorable case; it is easy to determine which end of the image is approaching, and which is receding, with respect to the nucleus. However, because the nebula is edge-on, it is not possible to detect the spiral pattern. When nebulae are tilted so the spiral patterns can be observed, it is curiously difficult to determine the direction of the tilt—whether the top or the bottom of the image is on the near side of the nucleus. In general, a definite answer can be given only when lanes or patches of obscuration are silhouetted against the nucleus itself.

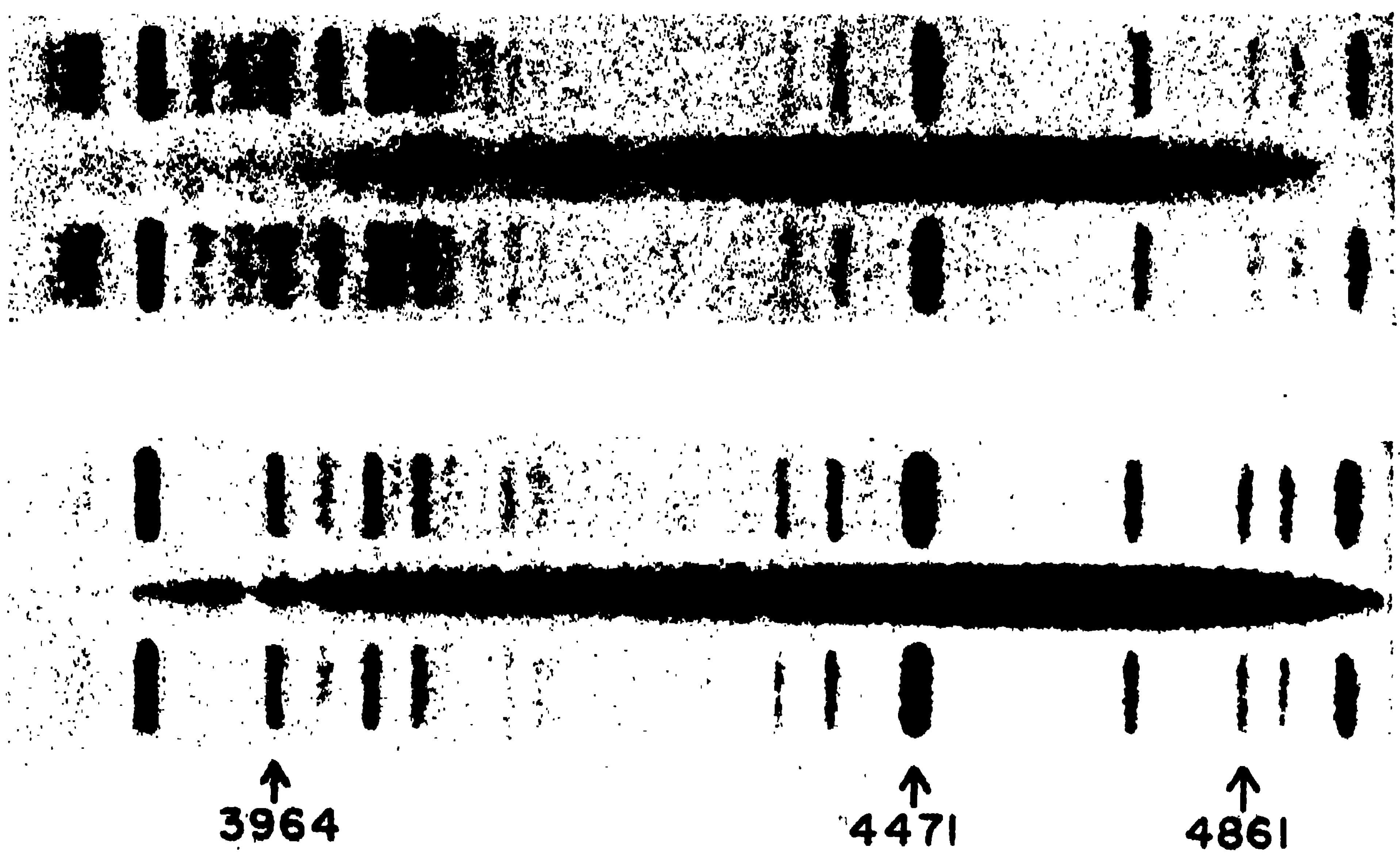
A recent exhaustive search among the 1000 brightest nebulae in the northern sky has led to a meagre list of three probably decisive cases. One has already been investigated, and, if the other two prove to be consistent, the problem may be solved. A similar search among barred spirals has isolated two or three nebulae in which the rotation of the bars can be tested. Thus, it seems likely that a firm empirical basis for theoretical investigations of spiral structure will shortly become available. The results will evidently form significant contributions to the ultimate problem of evolution.

Masses of Nebulae

The problem of nebular masses is in much the same state. The data are few, and their interpretation is confused but a way now seems open, and the solution is largely a question of time. Rotational patterns, or, at least, velocities of rotation in the extreme outer regions, may be expected to indicate masses once the patterns are fully interpreted. Meanwhile, it is possible to derive statistical orders of mass from the relative motions in pairs of nebulae. The problem is similar to that of double stars, and the same methods can be applied. However, a preliminary solution, based on about 20 isolated pairs, proved to be indeterminate because the differences in the radial velocities of components were so small in comparison with the errors of measurement that the mass effects could not be isolated. This result suggests an upper limit for the possible order of mass but furnishes no information concerning the actual order.

The next step is already under way, namely, the redetermination of the motions, using larger scale spectra for brighter objects, and multiplying the number of small scale spectra for fainter objects. The improved data will necessarily accumulate slowly. At the moment, the first 10 pairs suggest that the average mass of isolated nebulae is not likely to be greater than 10^{10} suns but, of course, the data are too scanty for confidence in this result.

Another approach to the problem is offered by the velocity dispersion, or range in velocities, observed within particular clusters or large groups of nebulae. The method was first applied by Zwicky, and, later, by Sinclair Smith, but the great increase in the number of radial velocities, due largely to Humason in the case of the clusters, and to Humason and Mayall in the case of the groups, suggests a reexamination. For instance, 55 velocities have been measured in the



RED SHIFTS, LARGE AND SMALL

THE UPPER SPECTRUM IS THAT OF A FAINT NEBULA IN THE BOOTIS CLUSTER (DISTANCE, 250 MILLION LIGHT YEARS), SHOWING THE LARGEST RED SHIFTS DEFINITELY ESTABLISHED. THE CALCIUM PAIR, H AND K, ARE SHIFTED FROM THEIR NORMAL POSITION NEAR 3964 TO ABOUT 4471, AND THE G-BAND, 4308 ±, APPEARS NEAR 4861 (Hβ). THE SHIFTS CORRESPOND TO AN APPARENT VELOCITY OF RECESSION OF 24,500 MILES PER SECOND. THE EMISSION LINE TO THE LEFT OF 4471 IS THE 4358 LINE OF MERCURY, REFLECTED BY THE SKY FROM THE VALLEY LIGHTS. THE LOWER SPECTRUM IS THAT OF NGC 3898, IN WHICH THE LINES ARE SLIGHTLY DISPLACED TO THE RED, INDICATING AN APPARENT VELOCITY OF RECESSION OF ABOUT 700 MILES PER SECOND. BOTH SPECTRA WERE RECORDED BY HUMASON ON A SCALE OF 500 A/MM AT Hγ. THE COMPARISONS ARE HELIUM, HYDROGEN AND NEON.

Virgo cluster, 30 in the Ursa Major cluster, 15 in the Coma cluster, and from 4 to 8 in half a dozen other clusters and groups. The dispersion clearly increases with the concentration of the cluster, as it should according to the known principles of dynamics, and reaches the extraordinary value of 1100 km/sec, found by Humason in the Coma cluster. The best determined dispersion is that for the Virgo cluster, 700 km/sec, also by Humason. The remaining values run from 150 to 500 km/sec.

The data suggest average masses of cluster nebulae of the order of 10^{12} suns or greater, and appear to be inconsistent with the tentative orders suggested by the isolated pairs and (provisionally) by the rotation patterns. Thus the problem of nebular masses is still in a highly unsatisfactory state. Nevertheless the problem may be regarded as in the process of solution. At any rate, the work must be pushed much further before theories to account for apparent discrepancies will be justified.

The Observable Region

In conclusion, we may consider briefly the progress in studies of the Observable Region as a unit. Here again, the preliminary, static description, based on the approximate distance scale, is already available. On the large scale, the distribution of nebulae appears to approximate uniformity. In particular, no sig-

nificant "gradients" have been established, there is no clear evidence of a "super-system," and, for broad statistical purposes, we may describe our sample of the universe as homogeneous and isotropic.

On the other hand, the small scale distribution of nebulae reveals a conspicuous tendency towards clustering. Nebulae are accumulated into clouds, clusters and groups of various sizes down to triples and pairs. Isolated nebulae are found, but they are the exception rather than the rule. Among the northern nebulae brighter than the 13th magnitude, about one in 8 may be considered as an isolated system. It is only when immense volumes of space are compared, in which the populations are much larger than single clusters, that the large scale uniformity begins to dominate.

This type of distribution evidently has real cosmological significance. Although the interpretation of the data is still uncertain, it seems possible that disciplined speculation, following the methods of multiple hypotheses, may throw some light on the controversial problem of the time scale. For instance, we might start from the alternative hypotheses, first, that the nebulae are clustering by capture out of an originally random distribution, or, second, that the nebulae are evaporating from clusters to populate the general field. In either case, solutions of the theoretical problems, on various sets of assumptions, will necessarily introduce the time scale. If it should prove possible to exhaust the available assumptions, the solutions might pin the time scale between definite limits. Zwicky has already discussed some phases of the first hypothesis, and, incidentally, has posed some embarrassing questions for the proponents of a rapidly expanding universe.

The dynamical picture of the Observable Region has not changed much in the last few years. New spectra, of improved quality, have confirmed the law of red shifts as previously formulated. The shifts (or apparent velocities of recession) remain strictly proportional to distance, within the uncertainties, out to the very limit of the observations. Humason has recently pegged the last reliable point on the relation with a fine 2-prism spectrogram of a nebula in the Boötes cluster. The apparent velocity of 39,000 km/sec confirms the earlier estimates, based on very small scale spectrograms, and establishes the point beyond question. The H and K lines are shifted more than 500 angstroms, and the ultraviolet spectrum has moved into the photographic range.

A critical review of previous investigations of the apparent distribution of nebulae leaves unchanged the conclusion concerning the interpretation of red shifts. No effects of expansion—no recession factor—can be detected. The available data still favor the model of a static universe rather than that of a rapidly expanding universe. In order to preserve the concept that red shifts measure expansion, it would be necessary to suppose that the postulated effects of expansion—the fading due to rapid recession—are actually present, but are nicely compensated by still another postulated effect—say strong curvature of space.

This statement presents the conclusions indicated by the available data. However, the most significant of these data lie at the extreme limits of the telescopes, where hidden systematic errors are ever lurking. For this reason, the evidence must be regarded as suggestive rather than conclusive, and the final solution must be referred to the 200-inch reflector now nearing completion.

The problem is still more confused by accumulating evidence which suggests that the law of red shifts does not operate within the local group—that is to say, within the gravitational field of a

group of nebulae. If radial velocities of the group members are not corrected for red shifts, the members appear to be nearly at rest with respect to one another—the group is stable. If the corrections are applied, the group appears to be rapidly expanding—a most unlikely behavior because such groups are too numerous to be regarded as temporary associations. This result seems to favor an expanding universe—the theory that the universe is expanding but, locally, the force of expansion may be overcome by the gravitational attraction of a group or cluster of nebulae. Thus, at the moment, the available evidence concerning the interpretation of red shifts is conflicting.

To summarize; a satisfactory preliminary description of a large sample of the universe has been sketched during the last 15 years, and the sample may be fair. An approximate distance scale has been established, and we know the general cosmography of the region, together with the structural forms of nebulae and the brighter elements of their contents.

The second phase of the investigations, the study of dynamical aspects or behavior of the universe, has been initiated, and is gathering momentum. Various fundamental problems have been formulated, and, for many, the ways to the solutions have been opened. A few of the problems have already been solved. But one essential datum, namely, the time scale, remains speculative, and, at the moment, we see no direct line of attack.

The immediate outstanding problems are, presumably, the interpretation of supernovae, of spiral structure and of red shifts.

THE PROGRESS OF SCIENCE

"Two hundred and forty years," I hear some one say, "what are they in the development of a nation, or of its scientific character? Twenty-five centuries have passed since Thales predicted an eclipse of the sun; nineteen, since Sosigenes reformed the calendar for Julius Caesar; fourteen hundred years have rolled over the University of Bologna. What to you occidentals seems a hoary antiquity is a mere yesterday for the dweller by the Tiber, the Thames, the Seine, the Danube or the Rhine." Be it so! Yet Hans Lippersheim's first suggestion of a telescope was eighteen months after Newport had sailed up the James River with his infant colony. The idea of a logarithm was then not born: Napier and Briggs were names unknown to fame. The oaks and beeches had been cleared from these hills, and our ancestors had built their rustic homes, at the time when Galileo was tortured into adjuring the profane doctrine that the earth moved, and not the sun. When Harvard endowed the college that bears his name, there was no such thing as a barometer or a thermometer. It is within these very two hundred and forty years that modern science has come into existence, and the world's intellect been turned from speculation to investigation. It is within this period that our implements of research have been devised, that the air-pump, the electrical machine and the clock have been invented, that every public chemical laboratory, every astronomical or physical observatory, and every academy of sciences has been founded. Boston had been settled when Keppler died. The grandchildren of the original colonists of Plymouth and the Massachusetts Bay were born, when the law of universal gravitation was first proclaimed by Newton.

Therefore it is that we must confess our scientific progress to have been far inferior to that of several European nations. And I fear that the confession might truthfully be made much broader, and include our progress in all purely intellectual studies, which hold forth no promise of immediate utility in promoting physical well-being or material convenience. If this is true, my friends, it is time that it should be so no longer. And before you, the declared lovers of science,—in this Association formed to promote her welfare and advancement,—here in the earliest seat of that colony, whence has geographically radiated what of culture and of science our country has possessed,—I would fain say some few words which, however crude or ill-arranged, might find a congenial soil within your hearts—to bear fruit, perhaps, when all of us have disappeared from the stage—and which might aid, in however small a degree, to avert the day when the highest recognized aims shall be toward material prosperity, rather than toward intellectual development and progress—*Benjamin Apthorp Gould (astronomer) Presidential address before the American Association for the Advancement of Science, Salem, Massachusetts, August, 1869.*

SOME ASPECTS OF CENTRAL AMERICAN BIRD-LIFE

I. FAMILY LIFE IN A NON-MIGRATORY BIRD POPULATION

By Dr. ALEXANDER F. SKUTCH
SAN JOSÉ, COSTA RICA

I

AFTER a decade devoted largely to the study of the habits of the Central American birds, it seems to me that the most fundamental and far-reaching difference between them and the birds of a region of great annual fluctuation in temperature, such as eastern North America, is that the majority of the tropical species dwell in the same localities throughout the year, while those of the temperate zone are, on the whole, shifting and migratory. I believe that the chief biological differences, as opposed to those of specific composition, between the bird populations of these two regions are related closely to the extent of their annual wanderings. And these, of course, are tied to the circumstance that in a region where snow and long-continued killing temperatures are unknown, the majority of birds find sufficient food on their breeding ground the year around; while in the so-called Temperate Zones, winter's dearth and barrenness send them afar in quest of sustenance—to another farm, another state, another country or another hemisphere.

A not inconsiderable proportion of the species of birds which occur in Central America are migrants which breed in the countries to the north. Whether these are North American birds which come south to escape the winter, or Central American birds that travel north to breed, is a question we need not attempt to settle here: suffice it to say that the majority of them spend, as species, from half to nearly three quarters of the year in the tropical portion of their extended range.

Of land birds which breed in Central America, I know only four species that perform migrations at all comparable to those of the great host of visitants from North America. In the parts of Central America north of Panamá, three flycatchers and a vireo arrive in February or March from the south, raise their families, then withdraw southward in September or October, if not earlier. One of these migrants is the sulfur-bellied flycatcher (*Myiodynastes luteiventris*), individuals of which go as far north as Arizona to nest; another, the noble flycatcher (*M. maculatus*) is very closely related to the first. The third is the striped flycatcher (*Legatus albicollis*), which has the disagreeable habit, apparently unique in its great family, of throwing out the eggs from the nests of other birds which build roofed structures, and using these stolen homes for its own offspring. The last is the yellow-green vireo (*Vireosylva flavoviridis*), a species exceedingly similar to our migratory red-eyed vireo.

In a region with extensive highland areas, and mountains rising up to heights of twelve and thirteen thousand feet, a certain number of birds perform seasonal altitudinal migrations. The Costa Rican bell-bird, which breeds in the highlands chiefly above five thousand feet, wisely avoids the worst of the drenching rains and chilling cloud-mists which assail these cold, wet heights, by descending during the rainy season into the adjacent lowlands. Hummingbirds of certain kinds, too, are seasonally abundant at certain levels in the highlands, usually when there is a profusion of flowers, and afterwards disappear. With so few observers

in the region, it is difficult to trace their movements.

But the majority of highland birds remain the year about at the altitudes at which they breed. I once spent a year watching birds on a certain mountain in Guatemala, where in the cypress forest above nine thousand feet the Guatemalan golden-crowned kinglet, a resident race of the familiar northern bird, was abundant; yet not once during the entire year did I see a single kinglet as low as 8,500 feet, at which level most of my bird-watching was done. This experience has been paralleled time and time again in the most varied localities with many species of birds; each has definite altitudinal limits above and below which it does not pass. Of two species which mingle at sea-level, one may range upward to eight thousand feet, while the other, less tolerant of lower temperatures, stops short at two thousand; but once the upper limit of the species has been ascertained, one will look in vain to find it higher.

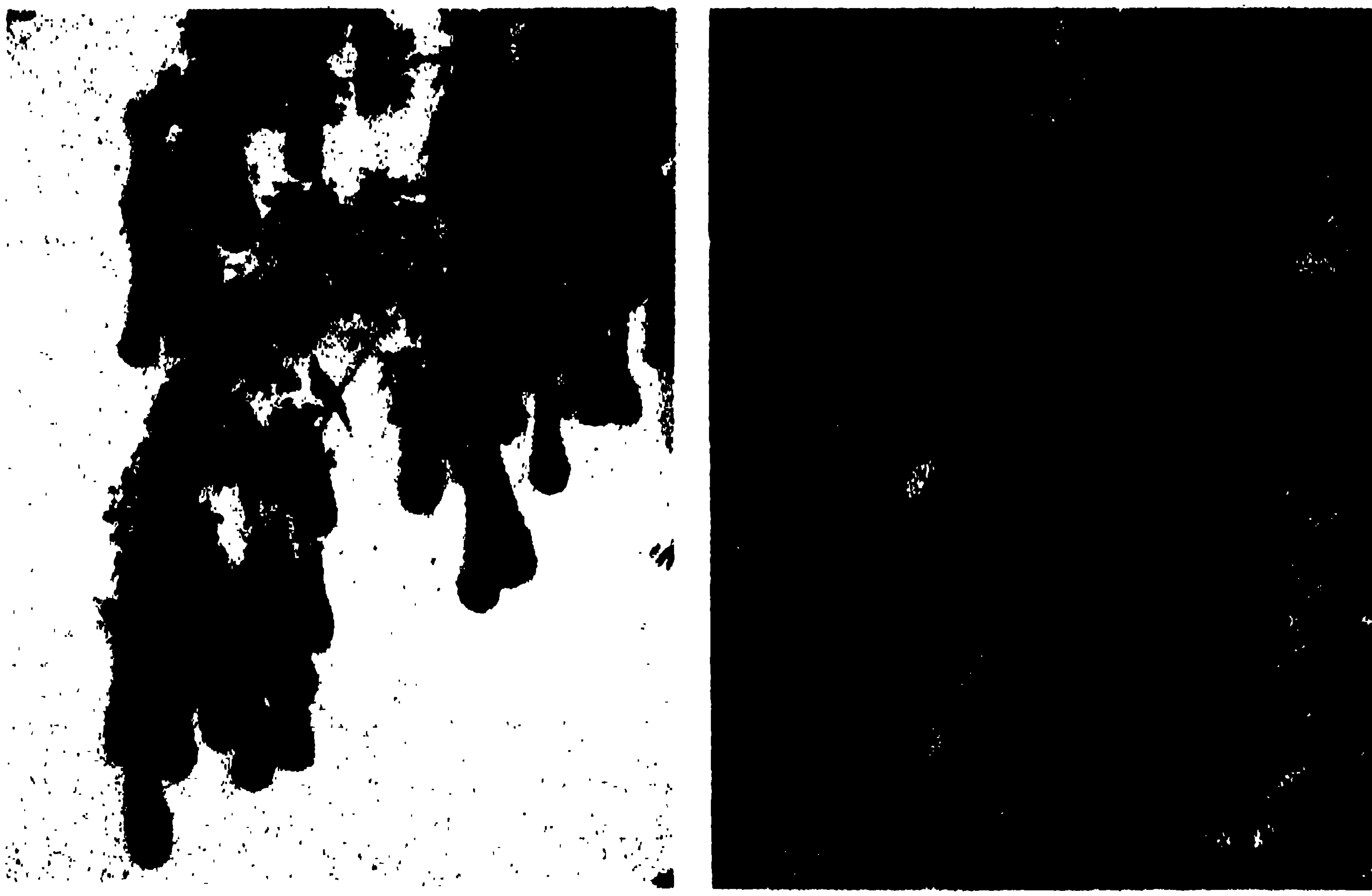
Another class of local migrations of tropical birds is well exemplified when, at the time of blossoming of the *guavo* (*Inga*) trees which shade the coffee plantations, hummingbirds and honeycreepers gather in great numbers to probe the clustered, white, powder-puff blossoms. Many of these, especially the former, may be of kinds which at other times are rare or absent from the district. Especially memorable is the great concentration of blue honeycreepers (*Cyanerpes cyaneus*) in the coffee plantations on the Pacific slope of Guatemala in December and January. From just how far these nectar-loving birds gather remains unknown.

But the species which wander in one or another of these modes are at best a small proportion of the whole Central American avifauna. The great majority of the Central American birds are sedentary to a degree difficult to be conceived by one familiar only with the shifting bird populations of higher latitudes. Not only does each species (with few exceptions) remain within fixed altitudinal bounds, but many are very closely attached to their own peculiar habitat, which they seldom voluntarily quit. There are numerous species of the heavy forest which scarcely ever venture beyond its shadow; while the denizens of the clearings may never penetrate as far as a hundred yards into the adjacent heavy woodland. Month after month through the twelve, one finds the same birds in the same thicket, the same field or the same forest. In a number of cases, while studying sleeping-habits, I have found the same individuals passing the night in the same spot throughout the year. The most striking periodic differences in the general complexion of the bird-population of any region of Central America are caused by the autumnal influx of the migrants which breed in the north, and by their departure in the spring.

II

In regions where winter is severe, the necessity to travel afar in search of food breaks up family groups at the end of the breeding season, for males and females, old and young, may have their separate times for beginning their journey. Or, if the birds remain in their nesting territory the year around, then the difficulty of finding sustenance during the cold and barren months causes the mates to separate, the struggle for individual existence proving stronger than conjugal ties. Thus it is said that in England the male and female of a pair of robins may occupy adjoining territories during the winter months, each opposing trespasses of the other until spring's mildness draws them together once more. Apparently the same may sometimes be true of the mockingbird in the United States. I am not sure that any species of the Middle Atlantic States—the temperate zone re-

HUMID LOWLAND FOREST ON THE CARIBBEAN FOOTHILLS, HONDURAS
THE HOME OF TROGONS, TOUCANS, ANTBIRDS, MANAKINS AND HUMMINGBIRDS.



COVERED NESTS OF CENTRAL AMERICAN BIRDS
Left: PART OF A TREE-TOP COLONY OF MONTEZUMA OROPÉNDOLAS (*Gymnostinops montezuma*), LARGER RELATIVES OF THE ORIOLES. *Right:* ROOFED NEST OF THE YELLOW-BREASTED CHIPSACHEERY FLYCATCHER (*Myiozetetes similis*), A COMMON BIRD OF THE LOWLAND CLEARINGS.

gion with which I am most familiar—actually remain mated over the winter. I suspect that Carolina wrens, and possibly white-breasted nuthatches, may at times pass the winter in pairs, but lack sufficient evidence to make a positive assertion. Unfortunately, since I became especially interested in this point, I have had very little opportunity of making observations outside the Tropics; and this is a point to which ornithologists in general have failed to devote the attention it merits.

But northern birds which remain mated through the year are certainly exceptional; while in Central America the kinds which do so are numerous. Not only do the male and female remain together, but in many cases they are almost inseparable, so that adult birds of the species are almost always seen two by two; or, if they are out of sight of each other, they keep in contact by their voices. When the species haunts densely entangled thickets where visibility is poor, it is often by the ear alone that the bird-watcher can convince himself that a certain bird, a kind of which he is fortunate to catch a fleeting glimpse of a single individual, lives in close association with a mate.

In a number of localities of Central America, both highland and lowland, I have made lists, based upon prolonged observation, of the species which live in pairs during the months when they do not nest. These include many species of tanagers, finches, wood warblers, wrens, flycatchers (Tyrannidæ) and woodpeckers; a few antbirds (Formicariidæ), ovenbirds (Furnariidæ) and motmots; two woodhewers (species of *Lepidocolaptes*); and the only gnatcatcher (Sylviidæ) for which I have sufficient observations. Orioles (Icteridæ) usually flock; in this family only Prevost's


OPEN NESTS OF CENTRAL AMERICAN BIRDS
Left: FEMALE NIGHTINGALE-THRUSH (*Catharus frantzii*) IN HER MOSSY NEST, HIGHLANDS OF GUATEMALA. *Right:* FEMALE CRIMSON-BACKED TANAGER (*Ramphocelus dimidiatus*) INCUBATING HER TWO EGGS, ISTHMUS OF PANAMÁ.

cacique (*Amblycercus holosericeus*) is on my list of birds which remain mated. I am certain of no thrushes which remain in pairs; but nightingale-thrushes (*Catharus*), of which there are numerous species, denizens of low and tangled vegetation, are exceedingly difficult to observe. Toucans usually flock; but I have known a pair of araçaris (*Pteroglossus frantzii*) to sleep together in old woodpeckers' holes through the year. Parrots and macaws, although they sometimes aggregate into great flocks, appear to remain mated, for the individuals which form these flocks, in certain species at least, fly and sometimes roost two by two, with usually some noisy and quarrelsome groups of three: triangles which remain to be squared.

Of great interest are the vocal sounds by which these constantly paired birds keep in contact with each other. For many of them a simple, sharp, characteristic call-note of one or two syllables does not suffice; their mutual affection and dependence on each other seeks expression in more complex utterances, common among which are churrs, trills and various other types of musical phrases. The male and female of some kinds, when they come together after a brief separation, greet each other with special utterances, sometimes of a peculiar, indescribable nature, at other times so musical that they have deceived me into believing that I heard the true song of the species. Some kinds of wrens, indeed, seem to lack true call-notes, although their vocabularies include a number of scolding and warning phrases. With them song is developed to a high degree as a means of keeping the pair together. Both male and female sing, frequently in antiphonal fashion; and singing back and forth to each other in rapid alternation, the voices of the two are so accurately

RIO CHIRRIPÓ AND WEST PEAK OF CHIRRIPÓ GRANDE (12,580 FEET), THE HIGHEST SUMMIT BETWEEN GUATEMALA AND COLOMBIA.

synchronized and harmonized that it is only when the hearer happens to stand between them, and hears their notes come now from one side, now from the other, that he can convince himself that he is listening to more than a single sweetest songster. The phrases of the male are usually somewhat longer and richer in tone than those of his mate. Doubtless it is because the constantly mated pair keeps in contact by song, rather than by simpler sounds, that wrens, more than all other birds, sing throughout the year. Most curious are the responsive utterances of the Prevost's caciques, jet-black icterids with sharp yellow bills, that haunt the densest thickets of the lowlands. The beautiful, mellow whistles of the male are answered by the female with a long, dry *churr*, as different as could be from his rich, round notes. It is only because I have, at all seasons, heard *churr* answer whistle that I feel sure these birds remain constantly mated: the ear is of more service than the eye in studying the ways of birds so retiring as these.

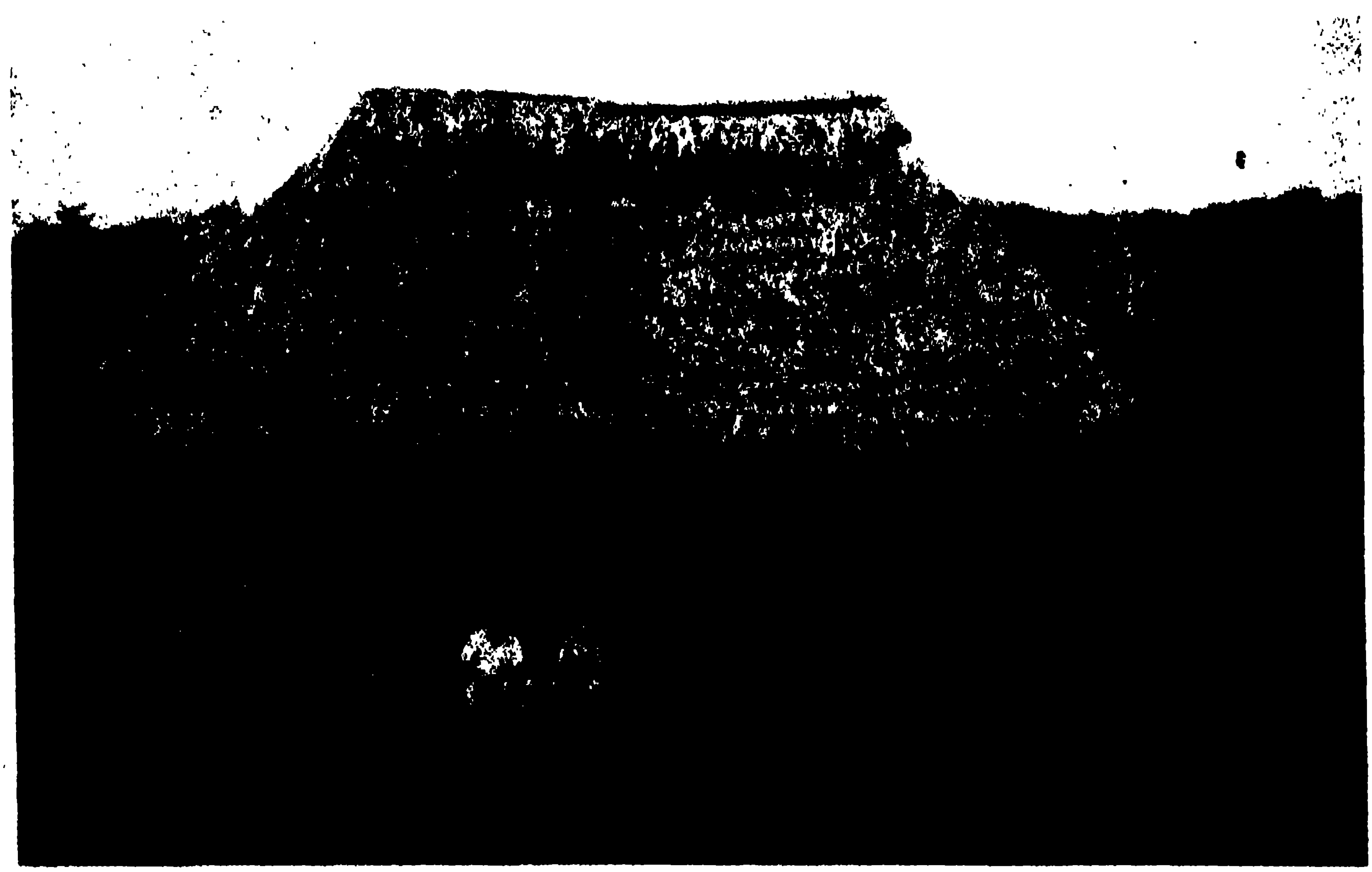
Lest the foregoing paragraphs leave a one-sided impression in the reader's mind, it may be well to add that in tropical America there exist several distinct groups of which the individuals never pair, and of which the males consequently take no share whatever in the care of nest and young. Notable among these are hummingbirds and manakins, of which the males in many species have very specialized habits of courtship, confining themselves during the breeding season to certain definite locations, which by their calls or antics, or both together, they make known to the opposite sex. Usually a number of males of the same kind, so calling or displaying, are grouped together into a courtship assembly, in which each individual has his own particular station; and these stations are mutually respected by the members of the group. Certain cotingas and forest-haunting flycatchers fail to pair; and the males of

some of these call for months on end from the same station. In certain members of the oriole family, including oropéndolas, caciques (*Cacicus*), and the great-tailed grackles, the females are far more numerous than the males, a situation which among birds usually gives rise to polygamy. The females of these species build their nests in populous, crowded colonies; the males keep watch over the nests and sound the alarm at threat of danger, but otherwise lend no assistance in the breeding operations.

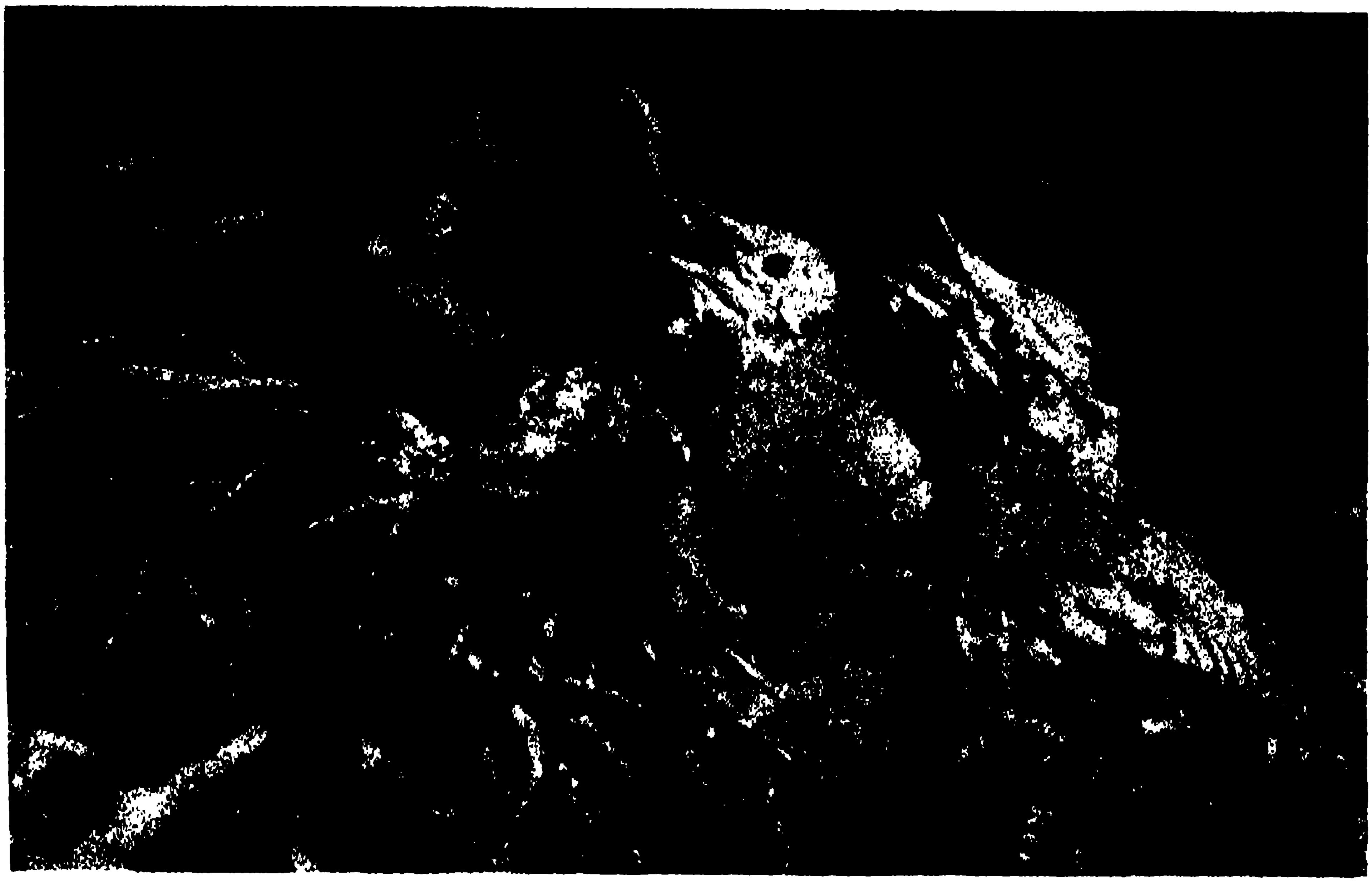
III

As a result of their generally sedentary mode of life; of the habit of many kinds of remaining paired throughout the year; of the adoption by other species of modes of propagation which make unnecessary the competitive acquisition of mates, the Central American birds on the whole seem to lead more tranquil existences than the feathered folk of extra-tropical lands. Although quarrels and fights certainly do occur among them, these appear to be of a milder and less hotly contested nature than those between birds of higher latitudes at the outset of the breeding season. The literature of north-temperate ornithology, especially that concerning territorialism, contains no lack of accounts of conflicts to the death between birds of the same or of different species. In the course of my own bird-watching, the preponderant part of it in the Tropics, I have never once seen one bird kill another in conflict, or even inflict serious injury upon another—excepting, of course, predatory species which kill for food. Only once have I seen a bird draw blood from another of its own kind.

Where birds have the entire year in which to adjust conflicting territorial claims, to settle amorous disputes, they may gradually come to an understanding without resort to violence. Where birds, arriving from afar, must claim their breeding territories, win their mates, build their nests and raise their young, all during a relatively brief season of



AUTHOR'S RESIDENCE IN RIVES DE PÉREZ ZELEDÓN, 1935–1937



VIOLET-EAR HUMMINGBIRD (*COLIBRI THALASSINUS*)
FEEDS HER NESTLINGS IN THE REMAINS OF THEIR NEST IN A CYPRESS TREE, HIGHLANDS OF GUATEMALA (9,700 FEET). THE MOSSY CUP HAS BEEN BURST ASUNDER BY THE PRESSURE OF THE GROWING NESTLINGS.

favorable weather, greater haste in the adjustment of disputes is imperative; tempers become overstrained; and fierce, sometimes fatal, encounters ensue. In human society we find an almost exact parallel to this situation. In long-settled, well-organized communities, acts of violence are far less frequent, in proportion to the population, than in pioneer settlements where property and personal rights are less firmly established; certainly the history of our own country gives abundant proof of this. Now the Central American birds, all in all, form a settled, static and generally peaceable community; the birds of an area in the temperate zones, with each returning spring, are a community of newly arrived pioneers, who only by strife and conflict adjust their differences and shake down into some sort of social order. Competition is no less keen in an old than in a new community; on the contrary, it is likely to be keener; but it acts in more subtle, less violent ways.

Perhaps some of my readers may recall that hummingbirds, a family represented in Central America by several score species, have a reputation for great pugnacity. Certainly no one can long watch these brilliant sprites without beholding one dart with apparent fury at a neighbor. But the object of the attack almost invariably takes flight; and there ensues a spirited pursuit, so rapid that the human eye can scarcely follow. Yet I have never known one hummingbird to inflict bodily injury upon another. I can recall only once having seen a hummingbird stand his ground as another dashed upon him. The two collided almost as lightly as two volitant tufts of thistle-down, and with results no more injurious to either. After years of attentive observation of hummingbirds, I am unable to decide whether they are the most pugnacious,

or the most playful, of our birds; but I suspect it is the latter. Surely their mode of courtship, where a number of competing males assemble to sing month after month within sight and hearing of each other, each on his chosen perch, would be impossible if they carried murderous intentions in their hearts. Even greater amity prevails in the courtship assemblies of manakins, and such flycatchers as Pipromorpha, for these apparently never even make pretense of attacking each other, but behave with a decorum and respect for the rules of the game which men might well envy.

Among the colonial-nesting Icteridæ—oropéndolas, caciques and grackles—it seems to be good breeding for the male who sees himself pursued by another to make a dignified retreat, leaving his perch free to the latest claimant for it. Thus these unoccupied males amuse themselves without serious dissensions; and in a good deal of watching of colonies of all three of these groups, I have rarely witnessed a flare-up between the males, never a real fight. The females, building their nests in close contact, sometimes fray each other's nerves, lose their tempers and set at each other with bill and claw; or else fights arise between them when one, too lazy to fly afield for more building material, attempts to pilfer it from a neighbor's nest, or even her very bill. But I have never known these squabbles to have serious consequences; and in the end the two females, who have quarreled so frequently while building their nests, settle down to incubate their eggs amicably side by side.

Most delightful to watch are the little Mexican grassquits (*Tiaris olivacea*). At the height of the breeding season one may see four or five males trilling sweetly in the same small bush, all in the best of humors. Yet the territorial instinct is by

BIRDS OF THE CENTRAL AMERICAN HIGHLANDS

Left: A FEMALE QUETZAL (*Pharomachrus mocinno*) AT THE ENTRANCE OF THE NEST CAVITY, ABOUT TO DELIVER A GOLDEN BEETLE TO THE TWO NESTLINGS. *Right:* NEST OF THE BLACK-EARED BUSH-TIT (*Psaltriparus melanotis*) WITH FOUR MALE FLEDGLINGS, HIGHLANDS OF GUATEMALA.

no means dead in these tiny finches. If one of them venture too near the nest of another, the owner will invite him to depart simply by flying toward him; and I have never known the trespasser to resist this mild suggestion that he is intruding, and make necessary a resort to force. On the other hand, a few of the Central American birds are notably pugnacious, outstandingly so the little, angry Lawrence's elænia (*E. chiriquensis*) of southern Costa Rica and Panamá. One morning, when I was sweeping out my cabin in the Valley of El General, one of these flycatchers, hotly pursued by a rival, brushed past me in the open doorway, and took refuge in a corner of the room. Yet although the *copetoncillo* is perpetually quarreling with his neighbors, I have never known him to inflict upon them damage greater than the loss of a few feathers.

Mildness of temper, then, seems to be a characteristic of the Central American birds, as a result—so I interpret it—of their leisurely, unhurried manner of life. I might fill many pages with personal observations in proof of this, but must content myself with one concerning that most original avian character, the Costa Rican tityra (*T. semifasciata*), a member of the cotinga family. Their nearly white plumage trimmed with black, their bare red cheeks, their thick black bills and their bizzare grunty voices, make them unmistakable in the Central American avifauna. For some weeks past, I have been watching a dispute between two pairs for possession of a tall dead tree which contains sufficient old woodpecker holes for the nests of both; but they are "territorial" birds, and the two will not breed so near each other. All four rest among the leafless branches; after an interval of repose one begins to grunt and twitch its tail in an excited fashion, then darts at a member of the other pair, who at once flits away. For a few moments they dash confusedly about, rarely so much as touching each other. Then, the brief flare-up over, they settle down to rest amicably side by side once more. Soon all four wing away in company to forage in the tops of the forest trees; after an interval they return together to resume their interrupted discussion. Thus they have whiled away the latter part of the breeding season, apparently deriving considerable diversion from their long-protracted argument, for it is resumed from time to time even now when it is very unlikely that either pair will nest this year in the contested tree. They have, of course, failed to reproduce their species—unless they raised very early broods elsewhere. But this is just as well, for if they are already so numerous that they can not all find cavities in which to nest—they are incapable of carving them out for themselves—they would only be creating worse difficulties for their kind if they increased their numbers. This is one means of avoiding that most pernicious disease, overpopulation.

ANT MOUNDS IN WINTER WOODS

By Dr. E. A. ANDREWS

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THE little ant hills of our garden walks disappear with bad weather, but the mound-building ant of the Eastern States, technically known as *Formica exsectoides* F., is able to gather and fabricate a ton or so of materials into a permanent home enduring through many winters.

When, in midsummer, we pause to watch the hundreds of ants busy on such a mound building and repairing it, we may at first overlook the fact that all roundabout are many more ants going and coming, foraging for food, but also, we find, prone to stop and test us with jaws and formic acid, fearing neither beast nor man.

In winter all is changed; we find no ants; the snow falls upon the mound as upon other objects and the ants are not roused by it as they are by the falling summer shower. Are the ants perhaps indoors enjoying a long Thanksgiving feast after the heavy labors of the summer time?

When the sun comes forth and falls upon the south slope of one of these mounds it soon melts the snow away so that, as in Fig. 1, we find the south face quite bare while yet the north face is white with snow. While this is but the familiar sun effect upon the plowed furrow that may be slimy mud on the south while yet frozen stiff on the north, in the ant mound the conical form makes the result very striking, indeed, just one half being white and the other brown. In the Alps natives found their way in the fogs by using certain ant mounds as compasses, since these were built by the ants more on the south, and in the same way many of our American ant mounds show differences between the north and the south faces. In the winter, however, we do not need the response of the ant to the sun in being more active on the sunny slope, but we can see at once from the sun effect where the compass points must be, even in the night time. Thus, as seen in Fig. 2, when the brown side is to our

FIG. 1. WHEN THE SNOW COVERS THE EARTH

THE SOUTH FACE OF AN ANT MOUND MAY BE SUN WARMED TILL QUITE BARE THOUGH THE NORTH FACE STILL STAYS WHITE.

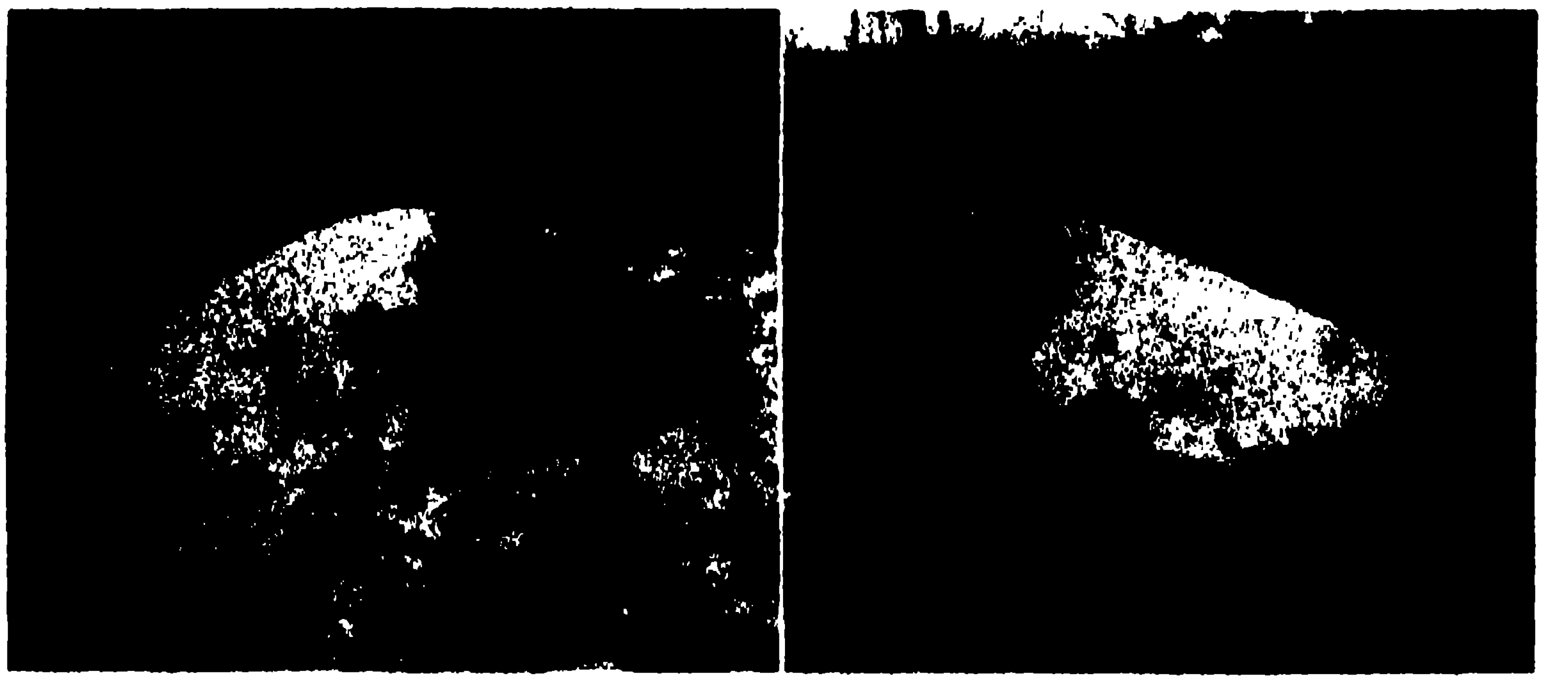

FIG. 2. MOUNDS IN FEBRUARY
ONE HAS THE SNOW MELTED OFF ON THE SOUTH FACE, TO THE RIGHT AS ONE LOOKS FROM THE WEST; THE OTHER SHOWS SNOW STILL LEFT ON THE NORTH FACE, TO THE RIGHT AS ONE LOOKS FROM THE EAST.

right we are approaching the mound from the west, and when on our left we are coming from the east.

But what has become of the ants which made these mounds so that records of compass directions are left for those who will use them? When the soil is loose, digging into such a mound is easy, but when long rain and frost have made it hard we may need a saw to cut into it as into an old-time sugar loaf.

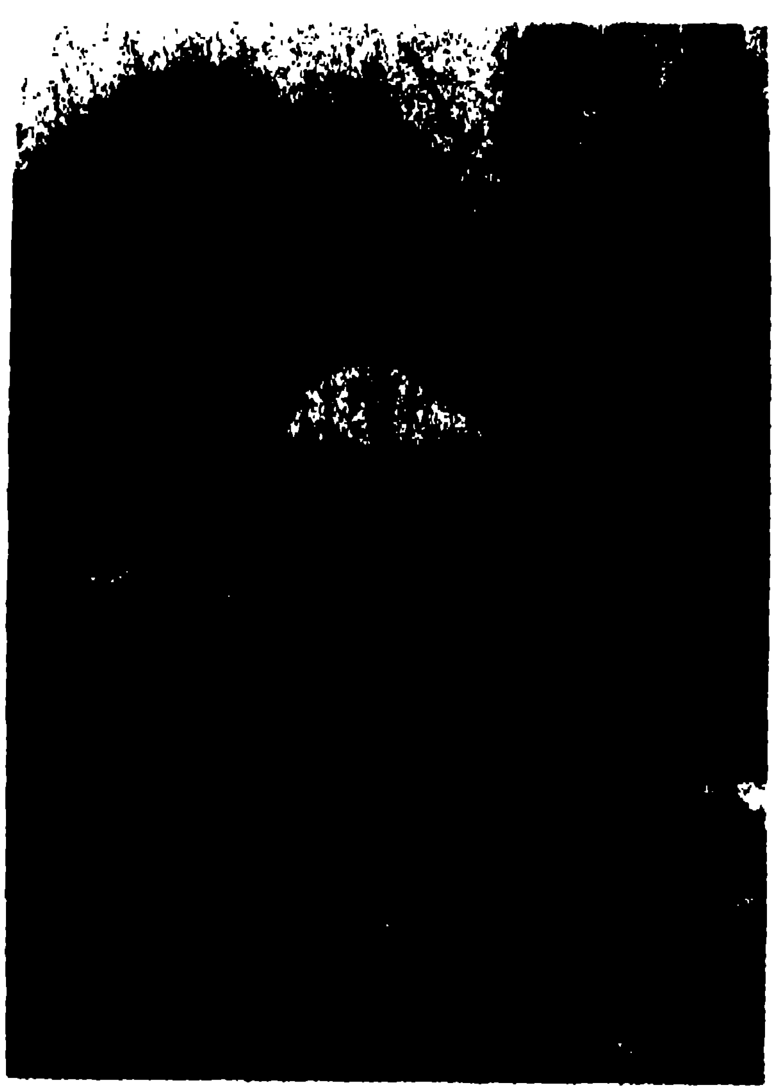

FIG. 3. THOUGH THE SUN HAS MELTED THE SNOW TILL THE WOODS ARE BARE THE ANT MOUND SEEN FROM THE NORTH STANDS OUT LIKE A PURE WHITE TENT.

Watching the ants in the fall we saw that, unlike men, who may move the more briskly as winter approaches, the ants move more and more sluggishly, but persist in working at the mound repair, even on into November if not too cold, gradually retiring day by day till few and then none are left above ground. Yet in our digging we do not find the ants in all the innumerable angles and turnings of the immense labyrinth that forms a continuous network of passageways through the mound—many parallel to the surfaces of the mound, many somewhat in stories connected by numerous "ramps." All much alike with no main halls. Nowhere are there ants to be seen till finally in the solid earth under the mound a few shafts descending from the network of passageways lead down deep into the subsoil and there in the cold and wet we dig out masses of ants—red and black bodies with intermingled legs oozing out of the narrow tunnels as if under pressure. Such ants are alive but scarce able to move. No longer running as they did at the rate of one mile in five or six hours when the thermometer stood at 86° F. or even in twenty-four hours when at 50° F. Now, at temperatures near freez-

ing, the ants stagger slowly along; yet if warmed and fed they remain active enough. Their life depends upon warmth and this comes to them from the sun.

Stores of food laid up in the ants' dwelling we do not find: apparently the ants go hungry nearly half the year through. However, the grasshopper perishes, while the ant lives through the winter, having made for itself a safe retreat where few enemies, even bug hunters, will penetrate.

As spring draws near the snow may still long linger on the north slopes of ant mounds, so that while from the south they do not show well against the brown leaves of the forest-floor yet from the north the mounds shine from afar, as if white tents (Fig. 3).

Eventually even this north cloak of snow melts and the sun heat penetrates deeper into the mound, arousing the ants, some of which venture up before others, sensing the differences between the cold below and the warmth above and seeking the warmer place, as in the fall they went down toward the stored-up warmth the sun had accumulated deep in the soil.

Coming out of their cold wet "go downs" the spring ants bask in the sunshine but soon set to work to repair the mound, washed by the winter storms, cracked with frost or even with dryness. Repair is proportional to need; holes made by feet of animals are filled in; even half mounds shovelled away by human fire-fighters may be restored completely by the hard-working ants. Soon, however, food begins to be found, stray insects and the first drops of honey-dew as the leaf buds begin to unfold. As the sun mounts higher day by day the ants' activity increases and breeding begins.

Children of the sun are these ants, building a house into which enters the sun as partner in their successes.

CHEAP BOOKS

NINE great publishing houses have decided to meet the "menace" of cheap books by publishing cheap books themselves. Cape, Cassel, Chatto and Windus, Collins, Dent, Faber and Faber, Heinemann, Harrap and John Murray are members of the new British Publishers' Guild, set up to sell books at 6d., 9d. and 1s. It is an attempt to restore the stability of an industry that has lately made very heavy weather economically, and a recognition of the merits of centralized and rationalized methods, both in production and distribution. The basis is cooperative effort. The whole stock of guild books will be delivered to the Book Centre, a limited company which will pack, invoice and dispatch the books to customers. In tune with modern business trends, a standardized and price-maintained article will emerge in the book world.

The new enterprise, still only very small and in embryo, is clearly an attempt to "cash in" on the gigantic sales made by the pioneer producers of sixpenny books—40,000 to 150,000 copies of each Penguin and Pelican were sold in the first year of their publication during the period 1935 to 1938. It is designed to thwart this rivalry by meeting it on its own ground. By issuing and maintaining "a first-class list of cheap editions," its sponsors claim, "the Guild will discourage the sale by authors and publishers of established books to organizations which have contributed nothing to their original success." This is the gravamen of the publishers' grievance against cheap books—as it always has been. Their contention is that names and titles "made" by their efforts are exploited to the advantage of others—a charge which loses some force by the fact that an appreciable number of the latest cheap books are original works or by unmade authors. . . .

That is what appears to be happening now. Publishers seem to have recognized, at last, that they can not swing against the stream; and that sixpennies are not merely a flash in the pan and economically unsound. They are a new and likely line of business. So, tentatively and with reservations, the publishers are going to adopt the principle which for so long they have fought against as being contrary to all good publishing traditions and trade ethics. This, and the failing financial vitality of the book industry, make up the background of the British Publishers' Guild. The regular publishing trade is to undertake the publication of special books at cheap prices, and their pooling of resources will create a great undertaking. It is the method of the cartel and centralized selling to protect a limited monopoly; but it is certain to meet sharp and efficient competition from the irregulars who have carved out a new market with skill and discernment. The public should gain by more and cheaper books, the community as a whole by more readers, and the book trade itself by new life after a long time in set ways and habits.—*The Economist (London).*

MICROBES IN A CHANGING WORLD[1]

By Professor SELMAN A. WAKSMAN

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THE role of microbes in the economy of nature was clearly foretold toward the end of the eighteenth century by the great chemist Lavoisier, to whom we are indebted for contributing to a better understanding of one of the most important reactions of the living system, namely, that of respiration. He said:

> Plants thrive at the expense of the air that surrounds them, of the water, and of the mineral kingdom from which they obtain materials essential for their organization; animals obtain their nutrition from plants, or from other animals also nourished by plants, so that matter thus produced is aways formed from the air and the mineral kingdom; finally, the processes of fermentation, putrefaction and combustion continuously return to the air and to the mineral kingdom those principles which have been removed by plants and animals. By what processes does nature bring about this marvelous cycle between the three kingdoms?

Fourscore years later (1862), Pasteur, emphasizing the remarkable insight into the processes of nature by Lavoisier, proceeded to disclose the secrets of the third process least understood at that time. He emphasized that "The destruction of the dead organic matter is one of the necessities for the continuation of life. If the débris of plants that ceased living, as well as of dead animals, were not destroyed, the surface of the earth would become covered with organic matter, and life would become impossible, because the cycle of life could not be completed." The link in this chain of life was found to be formed by microscopic organisms which, in the process of multiplication, bring about the destruction of complex organic materials by means of slow combustion accompanied by the consumption of oxygen.

Since the birth of the new science, microbiology, another fourscore years have elapsed. Many thousands of species of microbes, varying greatly in nature, in physiology and in functions, have been discovered; many have been isolated and carefully described. They have been found to occur in large numbers in the air and in the soil, in rivers, lakes and seas, in foodstuffs and in the digestive systems of animals. They comprise both friends and enemies of man. In his struggle for existence against natural forces, man has found in them able servants, laboring continuously and helping him in numerous ways in the production of his crops, in the preparation of his beverages, in the preservation of his foodstuffs and in combating many of his enemies. Occasionally some of the microbes went on a rampage and began to attack man and his domesticated animals and plants. Man, in his conquest of nature, is coming to recognize that he may be able to make use of the friendly microbes in combating the deadly ones, the causative agents of disease.

Great progress has been made during the past half century in the field of microbiology. But even now the methods and approaches in this field of science are undergoing certain important changes, which, as many are beginning to realize, may modify the entire attitude of both scientific workers and laymen toward microbiology, in general, and the utilization of micro-organisms for human welfare, in particular. From the early beginnings of microbiology, scientists have been searching for organisms which participate in the numerous beneficial and injurious processes that affect communities of plants and animals. The knowledge thus gained has been utilized to combat the activities of those organisms which are harmful to the health and economy of man, and to stimulate those which are beneficial.

[1] Journal Series Paper from the N. J. Agricultural Experiment Station.

Comparatively little interest has been shown in micro-organisms as biological entities, even though many of their functions have become known and their activities utilized.

Since the time of Pasteur, microbiology has traveled along two distinct paths, frequently quite apart from one another: one leads to the study of diseases of man, beasts and plants; the other is directed toward the microbiology of the soil, of water and sewage, and the utilization of micro-organisms in the industries and in the preparation of foodstuffs. The second branch is frequently referred to, quite incorrectly, as the microbiology of fermentations and occasionally even called general microbiology. A large body of knowledge concerning these infinitesimal forms of life and the relation of microbes to man has thus been built up. Many of the useful organisms have been domesticated, while many harmful ones have been combated and in many cases controlled. This has resulted in a complete revolution in medical practice and sanitation, as a result of which many diseases, formerly scourges of mankind, are now of negligible importance or materially controlled. If the newly gained knowledge has not served as effectively to revolutionize agriculture and related fields, it is not due to the lesser importance of the organisms concerned, but merely because man has made use of many of their activities since time immemorial, without giving them proper credit.

In attaining these ends, the microbiologist has largely availed himself of one method, namely, that of pure culture technique. This has been due primarily to the fact that, as causative agents of disease, single organisms are usually concerned. In those instances in which microbes live in complex populations, the individual organisms have been isolated from their environment and their specific physiology studied; their functions in nature were then interpolated. A number of problems, especially those pertaining to the activities of micro-organisms in causing disease of plants and animals and their functions in various natural processes, have thus been clearly elucidated. Unfortunately, comparatively little is known of the life of microbes in their natural environment.

The soil microbiological population may serve as an instructive example. It has been definitely established that soil harbors thousands of species of bacteria, hundreds of genera of fungi, actinomycetes and algae, numerous families of Protozoa, nematodes and other worms. These organisms are widely distributed and are often counted by the millions and hundreds of millions in a single gram of soil. Some are known to be concerned in highly specific reactions, such as the fixation of atmospheric nitrogen, the production of nitrite from ammonia, of nitrate from nitrite and of sulfuric acid from sulfur. Other reactions can be performed not by a single organism but by a number of different organisms: The decomposition of cellulose in nature, a highly specific process, can be brought about by various bacteria, possessing distinct morphological and physiological characteristics, by many fungi, belonging to widely different genera, by certain actinomycetes and possibly even by Protozoa and other invertebrates. The same is true of the decomposition of proteins, hemicelluloses, starches and other organic compounds. Some of the processes take place in chain-like reactions, in which one organism uses the products of another, in which one reaction leads to another, or in which the activities of one organism depend entirely on those of others. The decompositions of proteins in the soil, in sewage and in water are a good illustration of this type of transformation.

These processes, when considered singly and separately from one another, do not elucidate fully the complexity of the natural population, with its numer-

ous interrelationships. Considerable evidence has now accumulated which serves to emphasize the fact that not only do organisms assist one another in creating favorable conditions or in preparing the required nutrients; and not only do organisms compete with one another for the available foodstuffs, but many microbes exert a variety of other effects, regarding which there have seldom been more than conjectures or unsubstantiated hypotheses. In this connection one is reminded of the production by various microbes of stimulating substances, the nature of which is still unknown; and of injurious substances, comprising both toxins and phages, as well as the actual preying upon or consumption of some microbes by others.

These phenomena are recognized only by realization of the fact that the microorganisms form complex populations in the soil, in sewage, in water and in other natural substrates. The nature of these populations depends upon the medium in which they grow and upon the environment. One substrate, under one set of environmental conditions, contains a typical microbiological population. This population has a characteristic composition and consists of microbes which have become adapted to the particular set of conditions. When these are changed, the make-up of the population is changed. Winogradsky recognized in the soil population the existence of two distinct groups of organisms, one of which he designated as the autochthonous and the other as the zymogenic group. The first changes but little and only very slowly in response to a changing environment or to added foodstuffs, whereas the second responds rapidly to such changes.

Any attempt to explain and evaluate the numerous interrelationships in a microbiological population, such as that existing in the soil or in water basins, must take a number of factors into consideration. The following competitive relations have been recognized[2] among the marine forms of life: (1) competition among diatoms for the available mineral nutrients in the water; (2) competition among copepods and other animals for the available plant materials; (3) competition among individuals of one kind or species and individuals belonging to different kinds; (4) competition among young, growing and reproducing cells, and among older, respiring cells; (5) food competition *vs.* space competition; (6) competition of transitory and permanent populations for light, space and food, and (7) sedentary or sessile organisms *vs.* free-moving forms. One can enlarge upon this list by including other factors which are prominent in non-aquatic environments such as: (8) degree of tolerance of the immune or resistant varieties and the less resistant or more sensitive forms to attack by disease-producing organisms; (9) fitness for survival of microbes that are able to become adapted to a symbiotic form of life, as in the case of the leguminous plants or mycorrhiza-producing plants, and those which are not so adapted; (10) survival of parasitic forms which require living hosts for their development, as contrasted with survival of saprophytes that obtain their nutrients from mineral elements or from dead organic residues.

How can one interpret the interactions of different organisms making up a complex population without considering all these interrelationships? Pearl[3] emphasizes that, in any discussion and elucidation of population problems, three important factors must be considered: (1) size or total number of individuals comprising a given population; (2) growth, as measured by change in a given period of time, in a positive or negative direction, and (3) quality, or the nature or specific constitution of the population. These criteria apply to microbes as well as to men. Additional

[2] W. E. Allen, SCIENTIFIC MONTHLY, 49: 111, 1939.

[3] R. Pearl, *Amer. Nat.*, 71: 50, 1937.

factors are of importance in dealing with a microbial population which is quite strictly a victim of its immediate environment; (4) nature of medium in which the organisms grow; (5) abundance and nature of available foodstuffs, and (6) environmental factors, especially aeration, reaction, temperature, and moisture.

The differences in behavior of one organism growing in a pure culture from that during its development in a mixed population are illustrated by the following three examples:

1. Pure cultures of bacteria were found to multiply in a nutrient medium until a limiting population was reached;[4] this maximum was maintained for a long time. Protozoa grew in that particular medium without bacteria only when the concentration of the food supply was increased 100 to 1,000 times; when bacteria were present, they grew also in the dilute solution. The bacteria thus acted as collectors or concentrators of the food for the Protozoa. Bacterial numbers were thereby reduced, but bacterial activities continued. Oxygen consumption increased with an increase in the number of different organisms occurring together in the culture medium. The Protozoa kept the bacteria below the saturation point, thus providing conditions for more continuous bacteria multiplication and for more complete oxidation of the organic matter. In this connection, one may recall a theory which was in great vogue some years ago,[5] according to which the fertility of soil was believed to be based upon the interrelationships between the Protozoa and the bacteria. This theory assumed that bacteria are the sole agents responsible for the liberation of the elements essential for plant growth, in available forms. The Protozoa were considered as the natural enemies of the bacteria. By destroying the bacteria, the Protozoa were believed to reduce soil fertility. According to this theory, only when the Protozoa were eliminated, as by treatment with heat and chemicals, could the normal functions of the bacteria in the soil and, therefore, the fertility of the soil be re-established.

Further investigations did not support these conclusions.[6] It has actually been shown more recently that, by consuming some of the bacteria, the Protozoa keep the latter at a high state of efficiency and thus assist in the breakdown of the plant and animal residues in the soil. In other words, the rate of transformation and even the total amount of change in the substrate is increased by the presence of Protozoa; it has been observed that where Protozoa occur together with the bacteria, such reactions as ammonia formation, carbon dioxide formation and nitrogen fixation are definitely favored. Thus, an interrelation among micro-organisms which was thought at first to be antagonistic, actually proved to be associative.

2. In a study of the decomposition of complex plant materials, such as alfalfa, by pure and mixed cultures of microbes, certain striking effects were obtained (Table I).[7] A fungus, *Trichoderma,* known to be an active cellulose-decomposing organism, did not attack the cellulose at all and the hemicelluloses to only a limited extent, but it decomposed the proteins quite rapidly, as shown by the amount of ammonia liberated. When a non-cellulose decomposing fungus, *Rhizopus,* was also present in the medium, *Trichoderma* attacked the cellulose and hemicelluloses; the same was true when other non-cellulose decomposing organisms were present, such as the fungus *Cunninghamella* and *Ps. fluorescens.* On the other hand, when *Trichoderma* was combined with an *Actinomyces,* there was considerable reduction in decomposition of both the organic mat-

[4] C. T. Butterfield, *Public Health Repts.,* 46: 393, 1931.

[5] E. J. Russell and H. B. Hutchinson, *Jour. Agr. Sci.,* 3: 111, 1909; 5: 152, 1913.

[6] S. A. Waksman and R. L. Starkey, *Soil Sci.,* 16: 137–157, 247–268, 343–357, 1923.

[7] S. A. Waksman and I. J. Hutchings, *Soil Sci.,* 43: 77, 1937.

TABLE I
DECOMPOSITION OF ALFALFA BY PURE AND MIXED CULTURES OF MICRO-ORGANISMS, THE LAST COLUMN IN MILLIGRAMS

Population	Total decomposed	Hemicellulose decomposed	Cellulose decomposed	NH_3—N produced
				mgm
Trichoderma	9.3%	4.7%	0.0%	61
Rhizopus	9.6 "	12.8 "	2.9 "	53
Trichoderma + *Rhizopus*	13.7 "	22.6 "	10.6 "	63
Trichoderma + *Cunninghamella*	15.0 "	15.4 "	5.7 "	47
Trichoderma + *Bact. fluorescens*	10.5 "	14.5 "	6.4 "	32
Actinomyces 3065	16.6 "	43.0 "	23.2 "	52
Trichoderma + *Actinomyces* 3065	12.5 "	14.6 "	4.8 "	56
Soil infusion	28.4 "	40.9 "	50.8 "	21

ter as a whole and of the cellulose and hemicelluloses. These results further emphasize the fact that two organisms may either supplement and stimulate one another or exert antagonistic effects. In the above experiment, the total soil population was far more active than any of the simple combinations of micro-organisms.

3. As early as 1877, Pasteur[8] noted that the development of anthrax in sensitive animals can be repressed by the simultaneous inoculation of *B. anthracis* and various other bacteria. Subsequently, there have been numerous instances of reduction in pathogenicity of an organism by the presence of other organisms. The most striking illustration of this is the recent work of Dubos,[9] who succeeded in isolating from the soil a spore-forming bacterium which produces a substance destructive to all Gram-positive organisms. By using the method of soil enrichment, a method quite common to the field of soil microbiology, since the early work of Beijerinck and Winogradsky, he enriched the soil with the specific antagonistic organism; the latter could then be isolated in pure culture and its specific physiology studied.

Numerous other instances of associative or antagonistic relationships of micro-organisms in nature can be cited. Among these, the most interesting relationships pertain to the behavior of pathogenic organisms brought in contact with a native population, such as that of soils, sewage, or water basins. Jordan and associates,[10] and others, noted many years ago that *Eberth. typhosa* can survive a much longer period of time in sterilized than in unsterilized water; the presence of specific bacteria, such as *Ps. fluorescens*, reduced the survival period of the pathogen. The presence of bacteriolytic substances in sewage and in sea water has actually been established. Studies on the behavior of *Mycob. tuberculosis* in soil brought out the fact that whereas these organisms can survive in partially sterilized soil for long periods of time, under a variety of conditions, they are slowly destroyed in fresh soil.[11]

The destruction of pathogenic organisms in soil is believed to be brought about in four different ways: (1) unfavorable environment; (2) lack of sufficient or proper food; (3) destruction by predacious agents; (4) development of certain soil microbes which check the survival of the pathogens through the formation of toxic substances. Other still unknown mechanisms may also be active.

One may well inquire, what is the nature of the struggle for existence among the microbes and how does it express itself?[12] The answer would be that one is dealing here with highly heterogeneous populations, comprising numerous diverse species, belonging to various plant and animal groups and possessing distinctly different physiological characteristics. Some provide food for others,

[8] L. Pasteur, *Compt. Rend. Acad. Sci.*, 85: 101–105, 1877.

[9] R. J. Dubos, *Jour. Exp. Med.*, 70: 1, 11, 249, 1939.

[10] E. O. Jordan, H. L. Russell and F. R. Zeit, *Jour. Inf. Dis.*, 1: 640, 1904.

[11] C. Rhines, *Jour. Bact.*, 29: 299, 1935.

[12] G. F. Gause, "The Struggle for Existence." Williams and Wilkins Company, Baltimore, Md. 1934.

some assist others, some compete with others and some actually prey upon others or destroy them by means of other mechanisms. This expresses itself in the appearance of a balanced soil population, susceptible to change with alterations in the medium, in which the dominant types are those organisms which are well adapted to the environment.

Human and animal excreta and other animal wastes as well as plant residues, which are frequently both offensive and endanger health, find their way into the soil. Fortunately, they do not accumulate in the soil, which would have rendered it an unsightly, disagreeable and unpleasant body, which man would not dare to tread. On the contrary, the soil has assimilated all these plant and animal wastes, and has completely destroyed their undesirable characteristics. Through the ages, the waste materials of plant and animal life have disappeared, whereas the soil has remained essentially the same. The capacity of the soil to destroy and absorb these wastes is dependent upon the micro-organisms that inhabit it. Among these, the heterotrophic bacteria, the fungi, the actinomycetes and also the Protozoa are the active agents responsible for these purification processes.

The important ultimate products of destruction of the organic residues are ammonia, carbon dioxide, water and various mineral substances, such as phosphates, sulfates, potassium salts, etc. These are essential for the continuous growth of higher plants. All Chlorophyl-bearing plants synthesize carbon compounds from carbon dioxide and water. If heterotrophic organisms had not liberated the carbon dioxide in nature, all the atmospheric carbon would have become rapidly accumulated in the plant and animal bodies. All plant life would have ceased until devastating fires again liberated the carbon as carbon dioxide. If the carbon cycle, as well as the cycle of nitrogen and of various nutrient minerals were incomplete, the continued growth of vegetation, which is also the basis of all animal life, would not have been possible.

These facts are now well recognized and utilized. However, the ability of the soil microbial population to combat organisms causing plant and animal diseases is only now receiving some of its due consideration. One can only guess as to what may be revealed in the attempt to combat the dangerous microbes which lurk in wait of an opportunity to attack domesticated plants and animals, as well as man himself.

There is increasing appreciation of the probability that nature harbors many unknown organisms, and that we still have quite incomplete knowledge of the activities, potentialities and importance of many well-known microbes. We are at the beginning of a period of domestication of a new type of organism, which may help in combating the deadly enemies of man. Micro-organisms represent in this respect a totally different branch of biology in relation to human welfare. It is said that, since history began, man has brought about the domestication of very few plants and animals that were unknown and not utilized by primitive men. The micro-organisms represent in this respect a unique exception. Although man, in his struggle for existence, has domesticated and learned to utilize the activities of many microbes, notably the lactic acid bacteria, the wine fermenting, beer fermenting and bread fermenting yeasts, these represent only a small fraction of those micro-organisms which have become domesticated with recent years. It is sufficient to mention such organisms as citric acid producing, butyl alcohol and acetone fermenting, legume bacteria, and others concerned in industrial fermentations and in agriculture. We are finally approaching a new field of domestication of micro-organisms for combating the microbial enemies of man and of his domesticated plants and animals. Surely, microbiology is entering a new phase of development.

IS THERE A PHYSICAL BASIS FOR RACE SUPERIORITY?

By Dr. WILTON MARION KROGMAN

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ANY discussion of racial or biological superiority must rest on the basic assumption that differences exist between types of life, between divisions within any particular type and between members of the same division. Common sense and a little observation tell us that all these are true. We do not need a scientist to prove this by exact measurement and description. But the questions as to the magnitude of the differences and the fundamental character of the traits under consideration must be answered. In most popular discussions of race differences the assumption is made that superiority is a general trait in itself. This is far from the truth. There are several possible ways of proving racial superiority if it exists. The first of these is to make a catalogue of all the traits of man (Davenport has listed in "The Trait Book" a thousand or more of these), subject various representatives of different racial groups to carefully controlled experiment, and then balance the account to see where the majority of superior standings are. That is, the racial group showing a significant difference in, say, 51 out of 100 traits might be said to be superior.

A subsidiary method for proving racial superiority is to select a trait or a group of traits and make the determinations on this basis alone. This does not prove anything except that one race is superior to another in one particular feature or in a few specialized characters. In the end we would have no substantiation for statements as to relative superiority or inferiority. Actually this is what is done in popular discussions.

The third method, which is the most common and which has no scientific validation whatever, is to take the obvious differences on the physical side, such as eye color, skin color or a resemblance to a more primitive type, and erect on these data an evolutionary structure, assuming (to give an extreme example) that the more one resembles an ape physically the more ape-like are the mental and social capabilities.

One of the essential traits of man is that he is endlessly involved in sorting, classifying and cataloguing. The statistician is merely the n^{th} degree of the innate orderliness of the human mind. It is the tendency to classify that has led to this whole business of race classification and race evaluation. We are all collectors of one sort or another: be it stamps, coins, swords, books or knowledge. The quarrel is not with classification in and of itself but with the use of classificatory data when the person utilizing the material has nothing more in mind than the erection of a physical or social scheme of development. Much worse is the use of categories of incidental or non-functioning traits in building a philosophic hierarchy to explain the dynamic social forces which have been engaging our attention in late years. We shall hereafter focus our attention on anthropology and its classifications to learn in what ways the artificial groupings of mankind are different.

Much has been made of "survival value" in nature as evidence of varying degrees of innate superiority. Obviously, there are certain characteristics which serve to make some animals, in their own environment, reign supreme. If the pre-

sumed superiorities be analyzed they will fall into two major categories: structural and functional superiority. As examples of the former we may list such varying forms as the skunk with its scent mechanism, the porcupine with its quills, the ant-eater with its sickle-claws and its thickened coat, the rhinoceros with its horn and armored hide and the lion with its claws and fangs. In these forms there are morphological structures specialized for defense and attack. For our examples of functional specialization we may note the squirrel, blue finch and ant; here superiority is measured in terms of ability to provide for the young, to build nests, and the aptitude for social cooperation.

From these examples it is evident that superiority is not a single unit character, but that there are superiorities which, depending on the method of classification, might be reversed. And all "natural" superiority bows its head when confronted by a little lead pellet propelled by a steel tube with a superior "thinking machine" at one end of it—Colonel Colt was right when he referred to his invention as an "equalizer"!

It will be noted that in the foregoing classifications of natural superiorities or, better, specializations, we are dealing with differences which are intrinsically important and which bear out in general the theme that indices of superiority must be considered only when they check absolutely with performance. The fact that the leopard has a spotted coat and the zebra a striped coat, that one animal has curly hair and one has none, that even size within certain limits is incidental, must form the basis of further discussion. That is, superiority must be measured in something which is really important in a functional way. This point must be kept in mind as we consider qualitative and quantitative differences in man.

What of this superior "thinking machine"—man? How may he claim to be physically superior? His body is a veritable museum of vestigial remains; according to the biologists the human body has at least 100 useless structural elements, though formerly in man's evolutionary past they were of great service. Man! Biologically immature until 14 to 15 years; until then he can not reproduce his kind. Legally immature until 18 to 21 years: until then he has no real voice in his destiny. Socially, economically immature until 25 years or even later: not until then can he successfully become head of a family. In terms of rapidity of development most animals are superior to man; so also in acquisition of food, running speed and a host of other traits. Wherein, then, lies man's vaunted supremacy?

Man is distinguished from all other animals by the relative size and the elaboration of his cerebral cortex. There are, to be sure, animals with absolutely larger brains, as, for example, whales and elephants. The brain of a whale may weigh as much as 7,000 grams. We may demonstrate man's brain-mass superiority by noting several brain-weights at random: Lion 200-250 grams; horse, 600–800 grams; chimpanzee, 375–400 grams; gorilla, 400–500 grams; man, 1,400–1,500 grams, with an extreme weight of about 2,200 grams. If these brain-weights are calculated in terms of relation to body weight, then significance is obvious: Man, 45 :1; chimpanzee, 192 :1; gorilla, 200 :1; lion, 490 :1; horse, 746,1; whale, 10,571 :1.

These body-weight: brain-weight ratios emphasize the fact that it is not in mere mass of brain that man is superior. The characteristic in which man is presumably superior to the animals is found in terms of the quality of his mental reactions, *i.e.*, functional response in those aspects of life in which superiority comes because of a greater adaptability to the environment, involving reasoning, insight and creativeness.

By reason of man's achievements we can

safely assume that in comparison to other animals he is superior because of the greater substitution of thought and reasoning for hasty inconsidered action. On *this basis the hypothesis that superiority can be measured in terms of higher ranking in a majority of traits can not be substantiated. We have just seen that man's superiority is due to a constellation of traits having to do principally with the hig*her mental processes. Can we apply this to differences between races of man or must we return to an evaluation of multiple traits as a criterion?

It is time now that we define the term "race." Frankly, it is very difficult to do. In general, a *race* is a group united by blood and heredity; there is implied a continuity of the blood-stream and of the germ-plasm. In this sense race is identical with the general biological concept of a "breed." When we speak of *racial* characteristics, therefore, we refer to certain physical traits that are, within each group, predetermined by heredity and in which all members of the group participate.

It must be quite obvious that there are marked degrees of clarity in the elucidation of the hereditary pattern. For example, it is simple to segregate in the Nordic the blue eye, the fair skin, the blond hair; and in the Negro the brown eye, dark skin and black, kinky hair. But if one were asked to distinguish the brain of a Nordic and a Negro criteria of differentiation would be either lacking or so slightly developed as to defy classification in any given instance.

Just as hereditable differences are variable in their distinctness, so races themselves are extremely variable with respect to their constituent elements. By this I mean that degree of homogeneity varies. It is almost certain that no race or group to-day is 100 per cent. pure. Speaking in hereditary terms, what we call nowadays a *race* of man consists of groups of individuals in which descent from common ancestors can not be proved. In other words our basic definition falls in the presence of intermixture.

An examination of the physical characters by which races are *differentiated* discloses the fact that the principal categories are skin-color, hair-color and texture, and shape and size of the entire body and its component parts.

An Egyptain tomb at Thebes contains a series of paintings on the walls depicting four different types of mankind. That they are different we know by the color of the skin: Rudu, the Egyptian, is light red-brown; Nasi, the Negro, is black; Amu, the Semitic Asiatic, is orange-yellow; Tamehu, the North African, is white. To this day we classify races on the basis of skin color and recognize three main types: White (Caucasoid), Yellow (Mongoloid) and Black (Negroid). The Europeans still call the aborigines of America Red Indians to distinguish them from the East Indians. *Skin color* is a very obvious method of classifying races.

Closely paralleling skin color is *hair color,* hair texture and hair shape. Skin and hair color are virtually parallel phenomena, *i.e.,* light skin and light hair, black skin and black hair, tend to go together, though this relationship is not absolute. *Hair texture* may be classified as follows: straight, wavy, curly, tightly curled, and woolly, kinky or frizzly. Roughly speaking, the Mongoloids have straight hair, the Caucasoids wavy to curly, and the Negroids tightly curled to frizzly. *Hair shape* is classified much the same as the foregoing: straight hair tends to be round in microscopic cross-section, curly hair ovoid and woolly hair a flattened or kidney-shaped oval. The classification of hair shape is so extremely variable, however, that its import is greatly lessened.

The most wide-spread method of race classification—because it can be used for the living as well as for the dead—is the

famed *cephalic index,* which measures the ratio of head length to head breadth in the index $\frac{\text{Breadth} \times 100}{\text{Length}}$.

The index is classified as dolichocephalic or long-headed, if it is below 75; mesocephalic or middle-headed, if it is from 75 to 80; and brachycephalic or round-headed, if it is above 80. In general Negroes and North and South Europeans are long-headed; Anglo-Saxons, Polynesians and some Japanese and Chinese are middle-headed; Asiatic Mongoloids and mid-Europeans are round-headed.

The foregoing: skin, hair, head, are the principal methods of race classification. We might also linger over stature, nose form, facial proportions, cranial capacity, but we should only belabor our point: that the peoples of the earth do fall into more or less naturally defined physical types.

One of the first questions that comes to our minds is how long this physical differentiation has been going on. The answer must be given in terms of thousands of years. Physical (racial) homogeneity is not one of man's achievements. The Old Stone Age is written in terms of the Neanderthal, the Cro-Magnon and the Grimaldi races—the last named a Negroid type. Of interest to the anthropologist is the fact that all were long-headed. At the close of the Old Stone Age there appear, fully evolved, round-headed types at three widely separated points in Europe: Furfooze, in Belgium; Grenelle, in France; Ofnet, in Moravia. Racial differentiation and racial intermixture have age-old histories. The pace of the former has been retarded, of the latter accelerated, by the tremendous development of world-wide contact. In the face of this, "race purity" becomes but a shibboleth, for isolation is the guarantor, contact the destroyer, of racial homogeneity.

At this point we must inquire as to the origin of race types. Was man cast in one mold or several? If the former, which of the present day groups was basic; if the latter, what was the cause of the initial differentiation? These questions can be answered only in part. We run the gamut of theory from special unique creation to the polyphyletic theory of Crookshank, who would derive the Negroid from the gorilla, the Mongoloid from the orang and the Caucasoid from the chimpanzee (the last thought to be the most intelligent of the Anthropoids!).

The evolution of animal forms is written in terms of two factors: isolation and its corollary, inbreeding. The establishment and perpetuation of animal types are accomplished almost solely by segregation and its resultant lack of contact. These factors are certainly non-operative in the evolution of present-day human physical types. Man to-day recognizes no physical bounds, and if we read the record of the past aright he has rarely been baffled by geographical barriers (with the sole exception of the great oceans). We can, therefore, explain intermediate physical types as hybrids, resulting from race mixture. But how may we explain our basic types?

In recent years research has shown that the normal growth of the body is the result of the correct balance of the endocrine glands. This growth-regulating mechanism has been invoked by Bolk, Keith and others as the guiding force in the evolution of human physical types. To state their conclusions succinctly, in the Negroid the pituitary is slightly in the ascendancy, in the Mongoloid the thyroid exerts a slightly greater influence, and in the Caucasoid there is a state of balance which is rather inhibitive in its effect, so that the apparent hyper-endocrinism of the Mongoloid and Negroid is suppressed.

Here, then, we have a possible means by which the major types may have been

evolved. In our present state of knowledge the theory is to be recommended more for its ingenuity than for its actuality, yet it seems to be a step in the right direction.

Regardless of origin or cause the *fact* of racial differentiation has given rise to speculation concerning the *import* of racial differentiation. Are these differences the reflection of the retention of a primitive pattern, the modification of a basic type or the specialization of specific characters? In other words: do the races of man precipitate themselves into retarded groups on the one hand and advanced groups on the other; are there inferior and superior races?

There are, I think, two main approaches to this problem: the anatomical and the cultural. Let us consider the first.

Usually the assertion of physical differences is limited in this country to a contrast between the White and the Negro. It has, until comparatively recently, been part of the general cultural pattern to regard the Negro—or for that matter any non-White people—as an inferior race fit only to be subjugated; for the obvious differences in skin color, facial development, etc., early resulted in a comparison of "lower races" with the Anthropoids, a procedure which leads to the conclusion that the Negro had not evolved so highly as the White. The prognathism, the lower forehead, the dark skin, the wide nose, all seemed primitive characters. Modern research has now observed that the tightly curled or kinky hair of the Negro, his smooth, hairless skin, his thick lips, are specialized characters, in which the White is the more primitive. The theme needs no further elucidation: if the "specialized" and "primitive" bodily characters in each race—White and Black—be tabulated, it will be found that the credits and debits, so to speak, balance one another.

In 1856 Gratiolet stated that in the Negro "the cranium closes itself on the brain like a prison. It is no longer a temple divine, to use the expression of Malpighi, but a sort of helmet for resisting blows." Such a flight of poetic fancy implied that in the Negro the cranial sutures united very early, thereby rendering impossible the acquisition of further ideas, imaginations or knowledge; in short, denying any further progress toward civilization. The work of Todd has given the lie to this statement, for not only is the Negro's suture-closure pattern identical to that of the White, but step by step the Negro parallels the White in his anatomical development. The differences observable between the two are of the same degree, or less, than the differences observed in Whites of diverse socio-economic levels.

What shall we say of the brain within this cranium? Shall we follow Bean, of Virginia, who states that the cerebral pattern of the Negro forebrain is inferior to that of the White; or shall we accept Mall, who reports (on the *same* material) that interracial and intraracial variability is so great that it is impossible in a given instance to state the racial origin of a brain? It seems to me that the whole problem of the normal human brain narrows down to this issue: not so much what is there but how it is used.

About the sole criterion of general physical inferiority or superiority applied to all modern races is the question of disease susceptibility and immunity. This problem has been aptly summarized by Hrdlička, whose data may be tabulated as in Table I:

This is an interesting list, but it is not to be measured in terms of inferiority and superiority—nor did the author intend it to be. It would be absurd to do so, for then each group would in and of itself present a conflict of "superior" immunities and "inferior" susceptibilities. We must go much deeper than this. The true solution will be found in problems of

TABLE 1

Race	Susceptibility	Immunity
North Europe	Whooping cough (except Iceland)	Goiter Cretinism
Alpine region	Goiter Cretinism	Pulmonary diseases
Jews	Diabetes Cancer Nervous disorders	Tuberculosis
Negro	Tuberculosis Diseases of heart, lungs, kidneys Influenza	Malaria Yellow fever Measles Scarlet fever Diphtheria
Full-blood	Smallpox	Rickets
American Indian	Measles Tuberculosis Influenza	Cretinism Cancer Diphtheria Typhoid Mental diseases (except epilepsy)
Eskimo	Smallpox Measles Tuberculosis Iufluenza	Dental caries (until recently) Skin diseases Typhoid fever

isolation and exposure, and most certainly in considerations of socio-economic standards.

I think enough has been said on the problem of physical differentiation. It is an observable quantitative fact. It is not qualitative in the sense of the evaluation of "high" and "low" characters.

But what can we do in the face of statements like the following:

> The mixture of two races in the long run gives us a race reverting to the more ancient, generalized, or lower race. The cross between a White man and an Indian is an Indian; the cross between a White man and a Negro is a Negro; the cross between a White man and a Hindu is a Hindu. . . .

As a matter of fact, we can't do a thing! We can, however, turn to the very sensible observation of Todd when he discusses the placing of Senegalese troops in the Rhine region after the Armistice:

> So far as prejudice against colored people rests merely on color it is absurd and mischievous, but where the difference in color goes along with a complete difference in level of civilization, as was of course true of the Senegalese who formed part of this garrison, it is the difference in civilization that matters.

With this we come to the problem of superiority and inferiority in cultural attainments.

To my mind the whole question of cultural inferiority or superiority rests upon two very naive assumptions: first, that if the civilization is high, the aptitude for social development is correspondingly high; secondly, that a race is the lower in the scale the more it differs from the White civilization, which quite illogically is used as a basis for comparison. There is an utter disregard of the primary factors in the development of a civilization: time, events and contact. The three great historic centers of cultural evolution—of environmental pressures—were foci of racial movements: the Yangste Kiang, the Euphrates, the Mexican plateau. Here were born the civilizations that gave us the Oriental philosophies, the achievements of a Sumer or a Babylon and the awe-inspiring grandeur of the Mayan cosmology. Who may say which is superior to the other!

Very closely linked to the problem of social development, and also virtually a corollary of the problem of physical characters, is the problem of the mind—of mental ability. I think we shall accept the statement made earlier, that there is no real difference in brain structure among races, even though size of brain may vary from the Bushman average of 1,200 grams, or less, to the Chinese average of 1,450 grams. What about the problem of turning capacity into ability?

Earlier students of primitive people were prone to attribute to them extraordinary acuity of vision and hearing, and they assumed a corresponding elaboration of the areas in the brain given over to these senses. This viewpoint has given way to the common-sense realization that the *training* of the primitive hunter has but emphasized in one direction traits shared equally by all normal

persons. All experiments performed to test the sensory faculties of the several human races are tests not so much of race as of the average experience and habits of groups of different culture.

This is but one phase of the problem. We must look at mental ability in terms of the "intelligence tests." Are there innate differences in mental behavior which will permit one group to forge ahead of another in the keen competition between civilizations?

The answer must be in the negative. One can not deny that there are levels of civilization. We ourselves have passed through an age of chipped stone, of polished stone, copper, bronze, iron and steel. It is not surprising that the passage of time has been unequal in its distribution of contacts permitting the exchange of ideas. Whatever we may say, however many aspersions we may cast, civilization is not parasitic. Its roots are sunk deep in the firm ground of history, and it has been nourished by events and personages—mostly linked up with war, for the progressive movements of peoples have ever been associated with strife.

The fact of cultural differentiation is therefore no criterion of the ability for the development of culture. We simply can not measure this ability by any arbitrary standard. Our tests must focus upon the attainment of the group, in their *own cultural setting*, and not measure group achievement in terms of an attained level in a recognizable series.

This discussion can not be closed without recognition of the problem of nationality, which may be defined as an artificial grouping around a language as an expression of tradition and aspirations.

At the moment nationalism is rampant. It is based for the most part upon a conscious prejudice which strives to recognize a "we-group" and a "you-group." According to Keith this is the expression of an age-old endogamy and exogamy; he would take it still further back to the attempt of nature to achieve the isolation necessary to the rise and perpetuation of a definite physical type. Prejudice becomes a political weapon and nationalism emerges. If the process be thorough and long-continued, says Keith, then a nationality may become a race.

I can say but little of nationalism except that it has no basis in physical or cultural superiority. It rests only upon an appeal to sentiment and is a conscious effort to achieve solidarity based upon a common background and a common aspiration. The theory is splendid: the practice far too often is provocative and misguided.

I repeat the question: Is there a basis for race superiority? My answer must be that there are observable and measurable quantitative racial differences both as to physical and cultural development; but there are no measurable physical or social qualities which are in any given group superior or inferior.

Knowledge is slow of foot and
Wisdom limps far behind knowledge.

FILIPINO VILLAGE REMINISCENCE

By Dr. ELSIE CLEWS PARSONS
NEW YORK CITY

JOSÉ ALMENDRALA left his Tagalog village ten years ago at the age of seventeen and has lived since then in California or New York, but his Filipino life is not forgotten. Each day as we talked his boyhood in San Pedro, a bayside village in Laguna Province, became more and more vivid to us both. He remembered how he got through the wire fence around the *convento* and rang the church bell while the sacristans were not looking. Everybody lived by that church bell, one bell for Mass at 6 A.M., three bells at 10 for the second breakfast, two bells at noon for dinner, four bells for the afternoon prayer, a "little bell" at 6 P.M. for supper, and then, an innovation by the "new priest," a bell at ten for bed. Rice and fish made the meal, fruit also except at breakfast. Nobody would think of eating fruit in the morning, for it gave you a pain or gas, laughed José, thinking of American orange juice at breakfast. And he laughed over playing robbers the night of All Souls or of standing in the water-buffalo cart in the plaza Christmas afternoon when the child first to make himself shed tears or to let a coin slide down his face into his mouth would get the penny or a prize. He described the blowgun he used for shooting birds (what Spanish sailor or friar imported the blowgun from America?) or the cage without a bottom concealed over a nest and pulled down by a string when the bird sat on her nest, and as skilfully as ever he could make a bamboo and paper kite, with banana peel and a flower for the tail. He sang the planting song he had heard so often as he flew his kite near the rice fields lying between his house in the Centre and the shore.

> Rice planting is not all fun.
> Bending down all day
> I may not even sit down
> I may not even stand upright.

As the barefoot women in their Chinese bamboo hats sing and plant, men play their guitar-like *banduria* or beat their drum of carabao hide on the edges of the field. It is a village work-party, with a measure of last season's rice as pay and, of course, a noontime dinner in the fields. There are other work-parties for reaping or harvesting, for threshing or winnowing. Girls will winnow of an afternoon, tossing the rice from a basket and, if need be, whistling, like a sailor, for a breeze; everybody takes part in threshing, flailing the rice on a nipa mat to song and guitar, a night party, a time for courting.

In a population of about 800 only five or six men (the rich men, *mayaman*) own rice fields or sugar plantations, and these bring in one tenth of the harvests, the tithes, to the "Hacendero," just as they formerly paid them to the Jesuit monastery the Hacendero now occupies. San Pedro villagers are poor to-day because the "Castilas," the Spaniards, more particularly the "Huswidas," the Jesuits, appropriated the land, but why any tax is paid to-day on hereditary family lands José did not know or question. It is probably a survival of the barangay "tribute payer" organization (a barangay was composed of several "tribute payers" or family heads, controlled in turn by the head of the barangay).[1] In San Pedro tradition,

[1] J. R. Quirolgico. Ms., University of Nebraska, 1928–29. According to de Morga (1609) the barangay was a territorial unit. When the lord or possessor of a barangay gathered in his rice those that were of the barangay

under Spanish rule all forms of property were taxed or levied upon. To make him confess the number of his carabao,[2] José's grandfather was once subjected to the "water cure" (*tinutubig,*? ordeal water), the ingenuity used by the Spaniards and borrowed by American officers and applied not only in Luzon, they say, but in northern Mexico, in preference to the Conquistador way of toasting the feet. "Water plugging" in San Pedro, if not elsewhere, led to false accusations, for when a man was tied down in the plaza and the pipe run into his mouth he might charge any bystander with anything to escape the torture.

To-day house lots around the plaza, *i.e.*, in the Centre or in the six barrios, the outlying settlements, are levied upon by the "tail of the hacienda" or *escribiente,*[3] the tax collector of the hacienda, who will "cut the house posts," *tengaka,* of any one failing to pay. The tax collector, said José, was always drunk, and people would apply one of their numerous proverbs: "In spite of many legs [like the centipede] he too may fall."

House piles are cut pacifically when a house is to be moved. José recalled the moving of the family house in the waterside barrio of San Roque to a site bought by his father in the Centre. Cut free from its seven-foot piles and divested of its nipa mat walls, the thatched bamboo house was transported on men's shoulders during the noon hour when neighbors were idle, and then all the bearers, twenty or so, were regaled with cigars and fresh palm wine. To the little boys of the family it was a thrilling feat; to the adults it meant a move upward in society, from a "dying barrio" of country people to a centre of civilized interests, to the neighborhood of municipal building, of the church of the town's patron saint, of curacy or *convento,* schoolhouse, barber, stores and major market: to the Spanish plaza. And near the American railway station. The railway came through in 1910, making of San Pedro a potential suburb of the city of Santa Cruz and bringing it within three hours travel of Manila.

But as yet San Pedro remains an independent town or village with its own Centre and its own wards, its barrios. Each barrio, excepting Loúban, has its own little market, its chapel and its own patron saint. Loúban, garden or "backyard," is a sugar-cane plantation and people have only an occupational or seasonal residence there. Still they may refer to San Isiro (Isidro), the farmer's saint, as their patron. Landayang, the largest barrio, where about half the population live, San Roque and Kuyab are fishing settlements. At Landayang a woodcutter found the miraculous image of Jesucristo, who cures pilgrims bathing in his pool at his festival the end of May. The image is carried around the pool in a procession by night, and after this procession it always rains—"the miracle of Nazaret." Pilgrims who kiss the feet of the image believe that oil issues from them. ("Perhaps an altar boy has rubbed it on" was José's sceptical aside.) Pilgrims come from great distances. The image of another barrio, San Vincente, is miraculous against fire, having once checked a fire in its barrio. Kuyab's patron is Santa Ana; her festival is June 15. At San Roque's September festival his image is carried in a freight barge, with two men flourishing bolos in the bow to drive out the "devils," and there is a mock battle called *pagoda* between outrigger canoes trying to sink each other by paddle—

and under his "governance" went for a day to assist him, likewise if he built or repaired his house. "This chief, lord of a barangay, collects tributes from his followers and takes them under his charge to pay them to the [Spanish] tax collectors" (The Philippine Islands, 322, Hakluyt society, 1868).

[2] A rich man would have from fifteen to thirty; a poor man from two to five.

[3] Here as throughout I write the Spanish word as it is Tagalogized.

obviously an amiable acceptance by the saint of some pagan practice.

The barrio of San Antonio has been invaded by Protestantism, introduced by somebody from Malubon, a town in the adjacent Province of Rizal. San Antonio Protestants are strait-laced, foregoing smoking and drinking and cockfighting, and the people of this barrio are contesting the prerogatives of Dong Balencia (Don Valencio) their hacendero neighbor, also the toll imposed by the town on the wood San Antonio men bring in to market. There is no toll on produce from the other barrios, on fish, they argue. Betel nut trees are grown in San Antonio. Betel nut trees, by the way, are always owned apart from the land. Betel chewing, a woman's habit, said to prevent toothache, has not been given up by the Protestant women of San Antonio. Among these anti-Catholics there is said to be much cousin marriage. I would like to know more about these Filipino Puritans.

Between barrios there is normally a certain degree of rivalry or jealousy, traditional at least at the celebration of the town fiesta (*fista nang baian*) on May 1 and 2, when each barrio marches separately behind its brass band. In this *paséo* double quick, *paso doblé,* and in the plaza the bands try to outplay one another, and instruments may become weapons. Also if you go acourting by night in another barrio, as you are returning home the barrio "boys" may waylay you with bolos. At least one barrio is nicknamed derisively as fish eaters—*mangingisda.* Such attitudes are to be found in Mexican barrios and so are peculiarly interesting to students of Spanish America who are puzzled about the history of the barrio, whether it is wholly Spanish or partly Indian.[4] To any student of acculturation the barrio-Centre distributions of San Pedro would be interesting: Spanish culture concentrated in the Centre, native traits surviving in the barrios, where, for example, a man is not shaved at all but plucks his face with bamboo tweezers or where any afternoon women may be seen sitting in a row one behind the other delousing the head of the one in front, a delousing party, *kutuhang.* Other archaic barrio ways will come out as we continue our survey.

Perhaps the barrio of Landayang was the original settlement. For one thing not Saint Peter but Jesucristo of Landayang is the personage honored at the fiesta of the town, honored by Mass, procession and dance-drama, by greased pole, the "horses" (merry-go-round), cockfight and gambling, by fair, by blind or selfmaimed beggars and their blessings, and by feasting. You eat many dinners of roast pig; all your relatives invite you to their houses. José was twelve years old the first time he tried the thirty-foot pole from which waved a flag, and to which hung a bag of money, three pesos contributed by the rich. José used a hempen rope as sling around his ankles and the pole; and his uncle threw him some sand to rub on his legs.

The dance-drama, performed on a platform, is Moromoros, a version of the performance of Los Moros that was carried around the world by Spanish friars or colonists the better to celebrate their saints.[5] The Moors are in red, the Cristanos in blue. The Christian king or captain referred to as Mirabal sits between the two lines of soldiers and Moors; he wears a crown of bamboo and flowers, and the Moro girl or sultana called Manerba falls in love with him.[6]

[4] E. C. Parsons, "Mitla," 500–501. Publications in Anthropology, University of Chicago, 1936.

[5] Many dancers and musicians "represent dramas and plays in Spanish and in their own language very gracefully . . . due to the care and assiduity of the monks" (de Morga, 320).

[6] Compare Malinche in the Matachina dance of the Pueblo Indians and of northern Mexico, and the two little girls, one for Montezuma and one for Cortez, in La Conquista of Oaxaca.

The Moro king is threatening and insulting. Sword play, dance steps and dialogue which has been taught from a text by the *maestro.*[7] "*Embajador,*" princess, queen and her ladies (*damas*), who are three beautiful girls, and, of great interest to Americanists, a clown, *comidiante,* who dresses in red, wears an odd palm leaf hat and has his face painted white and red "so as not to be recognized," who imitates the others, tailing on to the line of Moors, picks up a bolo, smokes a cigar, gestures to the children, climbs posts, snoops up behind lovers and improvises jokes: all just like the behavior of Spanish-Indian clowns.[8]

In conclusion *pandango* (Sp., *fandango*) is danced, girls in one line, men in the other, to the guitar. Then the dancers sit down on the ground and are served palm wine and a meal off banana leaves. Still later the play of what Spanish Mexicans call *las piñatas*[9] is in order. A pottery jar filled with water or fruit or cakes is hung up, and the blindfolded hit at it with a stick.

This celebration has displaced that of Holy Cross, usually celebrated on May 3 but held in San Pedro on May 15. On the preceding nights of May the Cross has been carried in procession by young people who beg with a tin can, and each night the Cross is carried to a different house and kept there and the company entertained at supper. The last night a bamboo bower is built in the plaza. There is a dramatization of some kind: a queen guarded by soldiers is sentenced to death—that is all José remembered. In the afternoon a pole and ring game is played: boys spear rings hanging from ribbons given by the girls, the boys on bicycles instead of horses, the last direct word of the medieval tournament.[10] The girl's name is on the ribbon and she redeems it by a present to the boy.

Of Holy Week celebration, always in Catholic circles the ceremonial peak of the year, Palm Sunday is particularly well observed, at least according to the recollections of a boy. From four platforms, one on each side of the plaza, girls sing and children throw flowers on the procession with the saints. Palms are planted in the plaza, and as usual palm leaves are plaited into various shapes (but these are not charms against lightning, as among Spaniards, nor used in curing;[11] they are hung behind the house altar). For a certain period in Lent young men have gone about at night to read and pray in houses which contain the Cross or images of San Pedro or Jesucristo: a practice Dr. Beals has found highly formalized among the Catholicized Mayo-Yaqui Indians. During Holy Week women give up chewing betel. It is sinful to eat meat. No work is done. *People stay quiet; it is a dangerous time.* When the lights are put out in the Thursday evening service (*teneblas,* Sp., *las tinieblas*), it is said that "the world is collapsing."[12] *Penitentes* whip themselves with a leather metal-tipped thong, drawing blood, or they cut themselves with broken bottles. (Franciscans, the Third Order, as well as Jesuits must have entered the Islands.) In the Friday procession impersonations of the Apostles pull the cart containing Cristo in his coffin. Men fence with bolos, and sometimes get cut. For four days until the Gloria (Saturday morning, the ascent to Glory) the *matraca,* the wooden rattle, is used; they say Judas has stolen the bell. When the bell rings out, children

[7] Every barrio has its own dance master and dance company, who will be paid on visiting another barrio. Making a *promesa* or vow to dance, as in Mexico, is unfamiliar. Moromoros will be danced on barrio saint days and again at the general celebration of Kings' Day, January 6.

[8] E. C. Parsons and R. L. Beals, *American Anthropologist,* 36: 491–514, 1934.

[9] Compare "Mitla," 249.

[10] Compare "Mitla," 69; and the New Mexican or Yucateco or Guatemalan chicken pull.

[11] Compare "Mitla," 266, 510.

[12] Compare "Mitla," 268–269.

jump into the air to grow faster, and people shake their fruit trees to make them grow.[18]

We referred to the boys playing robbers on All Souls, which day or night in fact is called Lundras (Sp. *ladrones*, robbers). In the afternoon while families are visiting the cemetery or praying indoors and eating cakes the boys make of baked clay some sort of figure called *kalán* in the yard or garden and later in little gangs go around stealing chickens or turkeys or fruit. They know that if caught they would be beaten with bamboo or even slashed with a bolo, "but they are never caught." Sometimes they disguise themselves. They plan the raid days in advance and select their scouts (Sp. *espía*). One year José was the scout and diverted the attention of his Aunt Goria (Gregoria) of the barrio of San Roque while his gang were in her yard stealing a big *lanka*, a fruit much prized and well looked after. The tree indeed is sacred. When it exudes gum, people say, "God is asserting himself."

Christmas, Pasco (Sp., *Pascua*) is for José another memorable celebration. For the midnight Mass referred to not as elsewhere as *misa de gallo*, mass of the cock, but as *disperas nang pasko* (*vísperas de pascua*), the plaza is set all around with bamboo torches—the Christmas fires.[14] Young people walk and talk in the shadows, another chance for courting. Christmas morning José went with the other children of the family and his cousins from house to house, to uncles and aunts or godparents who gave them *aguinaldo, i.e.*, money or cocoanuts and, as they knelt and kissed the hand, a blessing. "*Tabe tabe nang poong* (or *Dios*), May God bless you!" José's little band always visited the store of the "uncle," who was the richest man in town and a former president. Finally the band of children would visit the *convento* and the priest would lead them to the church and sprinkle them with holy water. There was a family feast of roast pig stuffed with banana leaves, of special cakes of rice or bamboo, and a "ginger" drink, *salabat*. At this feast (*handa*) or any other, chicken entrails are inflated and hung on the house wall for "good luck."

On New Year's eve (Sp., *año nuevo*, T., *bagon t'aon*) paper lanterns are carried round. The band plays. In the plaza cakes are sold and bamboo "cannons" are exploded.

The general governmental set-up of San Pedro is, like the church calendar, much the same as that established by Spaniards in America: a council with presiding officer or *presidente* (*panĝulo*). The president is chosen every few years in general assemblage, by written ballot, through informal nomination by the councilors and inferably without dispute since the barrio voters are called derisively *kantatango*, "yes men." "They don't know what it is all about." Perhaps; for here speaks the sophisticated man of the Centre, who ridicules the accent or fish diet as well as the "ignorance" of his country cousins. Each barrio has a councilor or *teniente* (lieutenant), an executive who serves without pay indefinitely, "until people get tired of him." Every Sunday he is entertained at supper, house by house, and when he leaves everybody spins his plate around (clockwise, the circuit always favored by José) that no mishap befall the guest on his way, a customary conclusion to hospitality.

To-day, if not formerly, the president is paid in money. Paid also are a secretary, a treasurer, a postmaster and two policing officers (sergeant and corporal). Highway robbery or stealing carabao or rice seem to be the major offences. A judge, with authority superior to the president's, is sent from the capital of

[13] Compare "Mitla," 276.

[14] *Las Posadas*, the nine-day house-to-house visiting before Christmas, is unfamiliar.

the province. This judgeship, also the practice of paying municipal officers, are probably modernizations.[15] Of an earlier period is not only the unpaid barrio officer but the town crier, who holds office for life. He is appointed by the president to announce his orders, announcing generally in the evening, about nine o'clock, from barrio to barrio, perhaps droning out "nothing more important" than "the president directs you not to let your roosters run about."

The early Spanish terms, *alcalde* (judicial and military officer) and *principales* (former officers) are unfamiliar, although the president was formerly called *capitán*, and an ex-president is still so called. The town Socrates, José called his ex-presidential "uncle," as he tried for an American paraphrase. Local government has been changing, I believe, and terms and functions have been confused, at least in the mind of one who left town before he became a voter. Even so it was surprising to find that the Spanish cane of office was unfamiliar to José.

José's knowledge of life in the family is comparatively clear and full, even to details an American boy might ignore. While José's mother was pregnant that old-world evil-spirit prophylactic garlic, was hung around the walls of the house and at night his father kept his bolo close at hand, against the *asuwán*, a winged being peculiarly dangerous to pregnant women since he can steal the fetus. Once José overheard his mother telling some women of just such a case. A big pig was seen at the time rooting under the house. An *asuwán* can transform into a pig, a goat, a carabao, a snake or a man. He can steal your liver; he steals the liver of a corpse. Children are told not to go out in the dark lest they hear the sound of wings and the *asuwán* get them. "You will disappear." A wet cloth on the roof or wood ashes under the house as well as garlic inside will scare away the *asuwán;* but it is safest in pregnancy for a woman not to be left alone. As the Tagalog-American proverb goes: In union is strength.

Oddity or deformity will be set down to a prenatal cause. During one of her many pregnancies José's mother ate something sour and that brother is still a "cranky" fellow. In another pregnancy Manuela touched the head of a pig and the child was born with a "hairy ring" on his forehead. Because Manuela looked at the sun or at a calendar pictured with saints one daughter was blond and blue-eyed, like the Virgin. Looking at fish or at the moon may cause deaf-mutism or other defect in offspring. A child born during solar or lunar eclipse ("it darkens") will be dark-skinned (but not, as among Spanish Indians, deformed). During a solar eclipse, by the way, the village diviner will gaze into the water jar (as noted in Spanish America) and predict trouble, such as war. The women would kneel in prayer, as José once saw them do, and ejaculate, "God is punishing us! Why is he punishing us!"

There are both male and female midwives (*mangaganak* or *mangahilot*). To hasten labor the belly is squeezed. For slow labor a hot tile is put on the belly and on top of the tile the "olive-like" *kalambabit*[16] fruit is left to smolder. A root tea is drunk during the seven-day confinement, and for several weeks rice water made from rice first cooked dry. José remembers seeing his mother before the baby was born shake ashes from a cigarette into her mouth and swallow them; she said it was good for the baby.

Babies are baptized in the usual Catholic way, although they are not given the name of the saint on whose day they are born, not to-day at least. There are no Tagalog personal names, although José

[15] Yet pay for personal services to Spanish officials, to the friars and for communal work—weekly assignments called the *polo*—was customary (de Morga, 329).

[16] A San Pedro riddle: What do you put in your mouth and then (with gesture) throw away? Ans. *Kalambabit.*

thought "Juan" was one, "a real Tagalog name." Many Spanish words are supposed to be Tagalog; and even a slight phonetic change makes a Spanish word appear to be Tagalog. When I happened to use the Mexicanism *cabajo* (Sp., *cavallo*) in referring to the merry-go-round José looked surprised and exclaimed, "How did you know that Tagalog word?"

Nicknames are usually in Tagalog. One smallpox victim is called María Bulutonga, María Pox. Another María is Maríanbasa, Wet María, because she was once seen to wet herself as she urinated in the plaza. (People relieve themselves there or anywhere.) When Pablo's mother was carrying him she hankered for water chestnuts (*apuled*) and ate them. Her son's mouth was formed like one (Cupid-bow, we would say) and he is nicknamed Pablito Apuled. Siriaco the doctor is called Akong (Siriaco Tagalogized) Pisknot (noseless, ? a syphilitic). Macaria, a girl who "does not know anything" (*tana*) and at eighteen is still unmarried, is called Caria Tana. Acadio, once *jefe* or police chief, is known as Cajon Tinala, Cajon Chin-in-the-air. Nicknames may become patronymics. Dahōt, grabbing, is one because the father of the family once grabbed for some money when he was gambling. Supót, uncircumcized, is another, because the family head (another doctor) is actually uncircumcized. Such stories may be etiological, of course, but they also imply that the Spanish patronymic was adopted later than the baptismal name. Many townsmen are still known only by their Christian name, in the early European mode.

Some curious nicknames were applied, by the way, to the American military: "Kalambabit" (see above) because it sounds like much used Americano, "son of a bitch"; "labanus," a white plant; "*Americano* one two three *napote'e,*" American one two three dung (on the march the soldiers stank). *Bangos,* a white fish, was applied to Spaniards. Pampamgeño people, from whom were Aguinaldo's soldiers and betrayers, are nicknamed *dugonaso,* blood dog. The unbeloved Hacendero of San Pedro is a Pampamgeño, and he is the butt not merely of nicknamers but of satirical singers. Indeed Dong Balencia must be constantly biting his tongue, the sign some one is "thinking bad of you."

Between godparents and godchildren and between *compadres* there are the usual relations, with intermarriage forbidden. José was named *after his godfather,* who happened to be a priest living in another town. Whenever this *pare* (*padre*) visited San Pedro he would regale his godson with candy or popcorn. There are different godparents for marriage. There is no other class of godparents. I get the impression that the godparent relationship is not nearly as important as in Spanish America, where it seems to substitute for the extended family.

Marriage with any person your mother has wetnursed is also taboo; you call him or her brother or sister, as you do the child of a godparent.

Women have so much milk that sometimes they have to suckle a puppy. An infant is carried on the hip, by a woman; on the back, by a man. An infant or little child wears a necklace of bamboo with a cross as an amulet against the *asuwán,* if not against a bag-carrying, kidnapping bogey called *manǵunupot* (*supot,* bag). Another bogey, *nunud* (grandfather) or *unanu* (midget) lives in a mound in the yard and is angered if a child touches the fruit trees, mango or papaya or lanzon. We are reminded of the grandfather bogey who protects peach trees against our friar-taught Pueblo Indian children.

Schooling begins at six or when a child can crook his arm over his head and touch his ear. The course is for eight

years, but it is much interrupted by services due the household, such as herding carabao or looking after younger children. English is not spoken at home, but it is the school language, a very questionable requirement. José's English is neither grammatical nor idiomatic; he is not thinking in it, and this after living ten years in the United States. What kind of an instrument of thought was it in school? When I was in the Philippines in 1905 and visiting schools it seemed preposterous for all the teaching to be carried on in a language unmastered by either teacher or pupil,[17] and this view has not been modified. José hopes and believes that Tagalog will become before long the official and school language.

In or out of school children seem to have plenty of time to go swimming or to play. Girls as well as boys are good swimmers; girls will swim out to a steamer in the bay with a basket of eggs on the head. Boys play *sipak,* the general ball game in which the bamboo plaited ball rebounds from the body, hands not used; and of a moonlight night after parents are asleep boys will slip out to another barrio to accept a challenge and play a game something like hopscotch.

Theoretically family supervision or discipline is strict, with much respect for seniors. Parents are served first, the father sitting to the table on his own particular stool, a seat of honor. He crosses himself before eating as does all the family. Children kiss the parent's or grandparent's hand, kneeling, in the Spanish manner. Theoretically the father or male head of the family has the right to kill; instead he whips. José was unfamiliar with our expression of Mediterranean patriarchy, "Spare the rod, spoil the child," but he remarked that in San Pedro whipping is considered good for children. It is a very effectual sanction for obedience, for José says after he had to lie down on his stomach a couple of times when he was three or four years old and was whipped with a bamboo he grew afraid of his father and an order or, if strangers were present, a mere look was sufficient. Once his father whipped his sister, after she was married too, for insulting a cousin by calling her *butang inaamo* (Sp., *puta,* prostitute, *inaamo,* your mother), child of a prostitute. Another sister was whipped for objecting to a suitor acceptable to her father. Women will beat or slap their little maid servants (*alila*), and the girls in turn slap the little children of the family.

[17] E. C. Parsons, "Remarks on Education in the Philippines." *Charities and the Commons,* September 1, 1906.

Only the Hacendero and a few well-to-do families of the Centre keep servants, boys or girls given away by their father in return for their keep or to meet an obligation. Five children from a poor family in San Vicente work in the Hacienda for nothing, calling their mistress Tia Angé (Aunt María). José's mother had a servant because one year the rice crop failed and the man who was responsible for the crop, since he was working the family's field on shares, gave them his daughter. Unmarried mothers, girls who "have slipped and broken their water jar," may also become servants, since there is nobody to support them or their bastards. Much the same housemaid system is to be found in conservative Mexican villages, but in them the child of a servant would not be kept from playing with other children, as at San Pedro, or outcasted in any way. José, by the way, has a marked sense of caste or class; in making a town map, for example, he did not want to note on it the plaza houses of Nicolás or Pedro or Siriaco the cripple, all "insignificant" men. In what measures such discrimination is derived from Spanish culture or from pre-Spanish slave-holding Tagalog culture or even from American sources in or out of the Islands it is hard to tell.

Caciquism, the attitude, as Mr. Taft defined it, that 5 per cent. of the population was fit-to-govern and 95 per cent. only-fit-to-be-governed always dismayed the first Governor-General of the Islands, a very gentle and magnanimous democrat.

Certainly not American and not Spanish is one kind of discrimination in San Pedro: no village girl will marry an uncircumcized boy,[18] since he is considered incapable of begetting offspring. (The father of the family called Supót, Uncircumcized, had to seek a wife abroad. When children were born to him, they were imputed to another man; the village belief remained intact.) Circumcision is generally performed on boys aged eleven to thirteen, sometimes older. José was fourteen. Several boys will be circumcized at the same time, perhaps six or seven; but no formal relationship between these "comrades" is set up. The operation is done very early in the morning in the backyard of one of the boys by a specialist who has planted in the ground a forked branch on which the penis is to be placed, a kind of chopping block for the bolo. The boy is told to look upward and after the V-shaped cut is made he has to spit on the wound the juice of the goyave leaves he has been chewing and then to run a short distance as fast as he can. José recalls that he stumbled and they all laughed. The operator burns some goyave leaves and sprinkles the ashes on the glans which he puts through a jig to hold back the prepuce. For two weeks the boys stay in a little shelter in the bamboo-set yard, to have a goyave leaf decoction applied daily and to observe certain restrictions. They may not eat *malangsa, i.e.,* "anything slimy" such as fish, pork or beef. They must hide away from girls and not even think of them, lest the wound bleed from an erection. If a girl were around at the time of the operation the penis would swell. The foreskin is preserved in a banana leaf, as a suitor's certificate, so to speak, a marriage license.

Of his five "comrades" José remembers only three—Juliano, who happened to be a cousin, and who now goes around with an umbrella, the badge of the pig buyer, Mösis (Sp., Moïse) a seventeen year old who has since become president of the town, and the youngest, a ten-year old, who a year or two later was drowned in a pool near the bamboo bridge of San Antonio. A *sirena,* half fish, half woman, lives in this deep pool and sings and pulls down boys who are warned against throwing stones into the water or in any way making her angry. On the other side of the river women wash their clothes or sometimes with soapweed suds their hair.

Now and again a boy takes to women's ways and clothes, chews betel as girls do and joins their work-parties. These transvestites become expert workers, excelling women in women's work, especially as rice planters or as cooks, so they are very popular as foremen in planting or at fiestas. They do not marry; they indulge in moderate homosexual practices with young boys, masturbatory or caressing cheek-to-cheek. José expressed disgust for American forms of homosexuality, but he appeared indifferent to Tagalog manifestations. However, he knew one *binubae* (*bubae,* girl), effeminate, who must have experienced some disesteem since "*tired of being called binubae* he got married."

At first menstruation a girl must stay home protected against the *asuwán* by garlic in the house or on her person, for that winged visitant from the Igorrote province of Kapís "goes after virgins" as well as pregnant women. Menstruants at any time are expected to stay indoors and not to eat *malangsa* food.

Girls marry soon after adolescence,

[18] According to de Morga (p. 308) the practice was introduced into Luzon by Moslem invaders from Borneo, who preceded the Spaniards by a few years.

say at fourteen, boys a year or so later. There is some courtship at work-parties or fiestas, on the road after dark or in the yard, all surreptitious, or you may get a note to a girl by a little boy. Sometimes a girl's mother allows you to visit, always keeping an eye on you, however. Seduction is a "disgrace in the family," yet seduction or what might be called rape by magic occurs. A man will seize a girl as she goes at night to the store or he will go into her in her own house (*mangagápon,* one who crawls). Acquiescence has already been secured through various practices: he sits in a place the girl has just sat in and left warm; he puffs smoke from the side of his mouth into the girl's face; he crooks his little finger into the girl's finger. Or, if he is desperate, he visits the *mangagawai* and gets a cake to give the girl. The cake has been mixed with the suitor's semen and passed over his genitals. Seduction is broadcasted and bragged about. "I *nagápon* that girl."

José opined that women use no equivalent love magic (or magic of any kind). The girl's charm is in her face and hair; no attention is paid to the body. The complexion should be the typical sepia brown, not too dark. Long hair and "beauty spots," hairy moles, are beautiful. José has a mole near his upper lip which he says the girls envied. The girls will burn a spot on their skin and put charcoal into it to simulate a beauty spot. (More than one cowlick means you have had more than one father.) The nose should not be flat or the face "shallow." The slant-eyed, José calls mestizo, without knowing that the reference is or was once to Chinese descent. (Chinese or Japanese visitors, by the way, are not made altogether comfortable. The *nchik* or *chino* peddler who arrives now and again carrying his bottles by shoulder yoke is plagued by the boys, and Kato, the Japanese who has introduced the making of glazed pottery—he has a San Pedro apprentice as well as a Japanese one—is "under suspicion," as José puts it, without specifying. Kato's wife is Japanese.)

With marriage in mind a youth may go to a girl's father to ask for her, but that takes courage. "Pretty evening, sir!" says the suitor, too bashful ever to greet the girl. They talk of weather and the crops. "If they don't like you, they don't talk much." In such case the couple might elope, subject to pursuit by the girl's father with his bolo. Overtaken in a town, the runaways would be protected by the police.

When the suitor is acceptable or when old-fashioned parents have themselves arranged the marriage (there is no professional marriage go-between) and have the money in sight, as much as ten pesos for church fees and festivity (as there is little money in circulation in San Pedro getting married appears to "cost a lot"), the boy will bring a present of fruit or a bolo to the girl's father, and he offers his services in whatever work there is at hand, tapis clothmaking, netmaking, fishing or farming. For a year the boy will be *tested,* that is the way this kind of marriage by service is thought of, at least by José. During this time also the youth may be building his house, unless according to the more usual plan he and his wife are to live in his father's house, or unless for one reason or another they will live in the house of the bride. The man who lives with his wife's family may not have an easy time; he remains an outsider and may have to stomach from other members of the household such remarks as, "Lucky for you that you have a home with us!" Or perhaps, "You have long legs," the pointed comment made to any one who turns up too often at meal times.

José left home unmarried but not before he fell in love, with a cousin, the daughter of his mother's sister. "You can not marry her," his father said, "she is like your sister"; and he added the stereotype for utter condemnation,

"it would be a disgrace in the family." Any marriage between those bearing the same surname, since they are considered to be related, would be derided in town, a matter for *chismis,* gossip. Curiously enough José does not know that cousin marriage through the third degree is forbidden by the Church. He believes that the children of cousins will be defective, a belief he considers American.

Cousins are called indeed in the same way as brothers or sisters, young ones by name, elder ones by special terms in order of birth. Seniority is based not on actual age, but on age in relation to your parent, *e.g.,* you address as elder brother all the sons of one whom your parent calls elder brother, even if they are actually your juniors. This emphasis on seniority in terminology is consistent with the rôle seniority plays in family organization. To the eldest brother or sister, called *kuya,* the juniors of the household are obedient, particularly on the demise of parents. Inheritance is otherwise affected. The youngest in the family, *bunso,* whether male or female, will inherit the house and, if the family owns fields, perhaps the larger part of the land. Possibly the idea involved here, as in conservative Mexico, is that the seniors have married and have already been provided for. In Spanish folk tales, the youngest brother often has peculiar distinctions.

In the Centre the term *kuya* is no longer used for elder brother or sister or cousin, and uncle-aunt terms are the actual Spanish terms, *tio* and *tia.* "Only the most backward people in the barrios" use the Tagalog term for uncle, which is related to the term for father. (In Spanish America also it has been observed that the uncle-aunt terms may be the first to drop out of the Indian language.) Barrio terms for "my father" or "my mother" also vary from plaza usage. But everybody will still call uncle or aunt anybody their parent calls brother or sister. The "Socrates" José called uncle was not José's father's brother but his second cousin. Terms apart, any upstart junior may be reprimanded: "I have drunk more water than you have ever seen."

Kindred, whether in barrio or Centre, are very free-handed with each other. Whatever they have at hand, salt fish, dried fish, vegetables, they offer freely or they expect to be asked for them by any relative short of provisions. "Do you need this or that?" is a family amenity. Lending, *utang,* is a common practice. Nobody, either relative or neighbor, would ask to be repaid, that would be "committing a sin," but eventually loans are always repaid. In the market of course the attitude is quite different, and people will haggle for two hours or more over two or three cents. Kindred, also neighbors, are often invited in to eat cake and to join the household intent on praying for a bag of rice or a good harvest or for the recovery of something lost.

Divorce is unknown, nor would a woman leave her husband for any reason, not even if he beat her. He might beat her for adultery or even kill her. He does not beat her up when he is drunk. Filipinos are not violent when drunk, says José, they sing.

An elderly widow does not remarry; she would be ashamed before her sons and neighbors. Even a young widow who remarries is criticized by neighbors. "One man in her life" is standardized virtue for a woman. A man of any age may remarry; José says it is in fact Spanish custom for an older man to marry a young woman. However, this is not respectable in Filipino opinion, and in order to remarry a widower would go to another town where he was not known. José and his brothers would respect their father less were he to remarry. Their father is living to-day in Manila, and they do not know whether

or not he is remarried; "he might wish not to hurt our feelings by telling us." Their mother died ten years ago.

The family stood crying around her as she died. "Be good, be humble!" she adjured them in words traditional for a dying parent. "Forgive each other!" To quarrel is a disgrace in the family.

Any one putting his ear to the ground under the bamboo floor might have heard the bones of the moribund woman clinking, a curious variation of the death rattle. As soon as she died the mirrors were covered with white cloth, lest she be seen in them. To give her the last sacrament relatives carried the priest to the house in the church sedan chair (*palanquin*), an interesting instance here as in Mexico[19] of the persistence of archaic things in ritual.

The deceased was sprinkled with holy water (*bandita* from *agua bendita*) by the sacristan. She was laid out on a bamboo table, a crucifix in her hands, and her head to the house altar and the cross on the wall. A candle at each corner. At the wake, the "watching," the younger people played a game of forfeits, tales were told and then after they got tired of story-telling there was a riddling contest (*buktungang; buton*, riddle). Food was served. Prayers were said. People contributed money and flowers. Nothing was placed with the corpse in the coffin. Mourners beat their heads against the wall and wailed until they became helpless. "Don't you know God is taking her?" the others asked. "Will you defy God?" The band played for the funeral procession. The church bell tolled three times. For a man it would have tolled four times. At the grave, more wailing, especially by *bunso*, the youngest child. "How could you leave us?" the children cried, and tried to jump into the grave.

For a month no light was made in the house of the deceased, doors were kept closed and windows screened.

[19] "Mitla," 103 n. 90.

The ghost, *multo* (Sp., *bulto*, Tagalog, *kalalua*), may return within a few days to tell of something forgotten, particularly hidden money. José had heard of a woman returning to tell her husband about some money she had left under the bamboos in the yard and to enjoin him to take care of the children. All this is Spanish lore.

No novena is held for the deceased, nor memorial service. Only "fanatics" wear a black dress or arm band (says José, the modernist). Purgatory is generally out of the picture and except by the rich no prayers are made for deceased individuals, although at All Souls flowers and candles may be taken to the cemetery,[20] where only a very few who are not afraid stay on into the evening by the light of their bamboo kerosene torches, and eat their special kinds of rice cakes and "bamboo cake."

José did not know what his mother died of; she was only thirty-five. She had eight children and had suffered four miscarriages. When José was eight years old he got hookworm, from tossing pennies on the ground, he thinks, and was taken to the hospital in Manila to be cured. In town there are two or three doctors called *mangagamok* (Sp., *albulario*), who set broken bones, treat headache by applying a leaf to the forehead, give internal herb medicines, and counteract black magic. Various ailments are attributed to magic or to poison (*manalasung*) put into the household water jar. Epidemics are caused by such poisoning. During a cholera epidemic American officials prescribed boiled water; but people did not like the taste and when word went around that they would become bald like Americans if they drank boiled water they stopped boiling it.

Spanish witchcraft and Spanish village curer may be recognized at San Pedro,

[20] Situated in the barrio of San Antonio since American occupation; formerly burials were made in the churchyard.

although the usual Spanish terms are not familiar to José, and non-Spanish elements seem to be involved. The *mangagawai* (or *mangkukulan* [one who makes sick]) works his black magic through a small wooden doll (also called *mangagawai*) into which he sticks pins or anything sharp to injure somebody. The doll is used particularly as a spite charm against women. The woman will twitch at the moment the pin is stuck into the doll.[21] Her leg will swell up or she will waste away or she will act crazy,[22] if that is the order to the "doll." The woman may tell her husband who it is who is doing this to her, perhaps a rejected suitor, on his own or through a *mangagawai;* and her husband will catch the man and threaten to kill him. The *mangagamok*—"quack doctor" José calls him—also may discover the *mangagawai,* by sticking a pin or a rice pitchfork into the *nagawaí,* the one bewitched; this makes the *mangagawai* cry out. Burning the doll will make the *mangagawai* sick. Theoretically a *mangagawai* may be hung or burned, but as anybody feels flattered to be called *mangagawai,* according to José, there is probably no danger of an execution, at least to-day.

A *mangagawai* takes offense very easily. You may only have stepped on his foot or answered him in some way he doesn't like. He does not threaten; he has only to show himself near his prospective victim's house for the person to be terrified. Everybody is afraid of him. Men know he has immunity against their bolo. When a family kneels before the house altar in evening prayer to ask for food or for whatever they want—the mother asks and the others repeat after her—they also ask to be delivered from the *mangagawai,* from anybody who can make them sick. You must never show anybody, not only the *mangagawai,* that you do not like him; he may make you sick. Frankness is not merely a lack of courtesy, it is dangerous. Formality is self-protection. With strangers José himself always used stereotype phrases and looked blank. More than once I saw his responsive face suddenly become a mask when we heard footfalls outside the cottage window.

Fear of witchcraft is certainly Spanish, but praying at the house altar for deliverance goes beyond any Spanish practice I know of and suggests some pre-Spanish belief or fear. "*Guniguni,* fear. Our people live all the time in fear of something," opined José. They fear the sun as a god (*poon*) and so at noon or sundown they stay indoors. They are afraid of the dew and of the wind which hits[23] and sickens you (both these apprehensions are probably of Spanish origin). Sin will be punished, *pinibabia,* it is being paid, they say or, *tagalang na Dios,* it is the wish of God, and they are afraid. "María José!" a person cries, if he stumbles, "I am already feeling it." A person is always afraid that something will happen.

There are poisonous snakes in the rice fields (the wound is to be licked by a dog, then ginger is applied, and ginger is given to drink; if despite these remedies death ensues it means that the victim was a sinful man, "God wills it"), but

21 Unlike the witch of Spanish Indians, the *mangagawai* does not send anything into the body of the victim which has to be sucked out by the doctor. This is purely Indian practice in contrast to the witch doll technique of the Spaniards.

22 Craziness or neuroticism in a man are otherwise explained or treated. The two insane men José recalls were kept tied to house posts, in the medieval way. Their affliction was imputed to violent experiences: Antonio became insane during the Spanish-American war; Akong, a young man, after he had been tied to a tree and slashed with bolos. The man who broods and then with his bolo runs amok (*sirasiraulu,* broken head, or *masamentau,* bad man, Sp., *loco, juramentado,* ? under a vow), killing "to satisfy his anger," is cured by the *mangagamok* with a root decoction. The condition is ascribed to wind or to heat. It is rare in San Pedro.

23 *Natapal nahang,* the wind slaps, apparently a translation of the Spanish, *se pega aire.*

people are also afraid of the "sleeping snake," a house snake into which at death the eldest son of the house is transformed. (Ancestral snake cult?) Beyond the barrio of Kuyab lives a woman said to be married to a snake. (In the sugar-cane barrio the story goes that a woman is married to a monkey. They have offspring, conceived through the ear.)

People are afraid not only of a whirlpool but to cross any river, perhaps because of a mythical big fish called Bwaiya which can swallow not only all the fish in a river but man or child. "If you do not behave yourself Bwaiya will come," a child is threatened. "It is the wish of God."

Both children and adults are afraid of Tikbálan. When José was small he got lost once in a sugar plantation and began to call out, *Mare, Mare!* Mother, Mother! Tikbálan kept answering, Here! Here! and José followed until he knew it was Tikbálan leading him astray, and he turned his jacket inside out and found his way out of the field. Tikbálan means locust, the destroyer of rice fields, but the spirit of Tikbálan who leads you astray is described as half man, half horse. Tikbálan can also transform into a beggar and if you give him food he can make you sick. If you give him fire your house will burn down. Against such appearances of Tikbálan you may be protected, if not by a hard heart,[24] by Sakai.

Sakai was the leader of a mountain band who fought the Spaniards and when shot at were able to disappear in smoke. Sakai came down into the town and incited people to rise against the Spaniards. When they beat the Spaniards Sakai was their leader, although he remained unseen, and people were grateful to him. Then he withdrew into the mountains. When the Americans came and opposed the people, Sakai came out again, but he could do nothing against the Americans, so he withdrew again to the mountains where he continues not only to afford protection against Tikbálan but to be responsible for good harvests and for hospitality to travelers. Such hospitality is "Sakai's work."

Other cults or magical ways were mentioned by José. There are sacred carabaos: white animals or animals with crumpled horns curved peculiarly up or down. These beasts are not turned out to pasture off rice stalks or zacate grass but are given special fodder, bathed daily and not worked. There must be much more to tell about this, but all I learned were a few tales about the *bakang* (Sp., *vaca*) *ginto*, the golden bull that lived on Makiling mountain, an enchanted or sacred mountain not far from San Pedro, or pastured at the foot of Taal volcano and then went down under the waters of the lake. When American soldiers shot at him he got angry and withdrew into one of the crater lakes so the volcano erupted and caused an earthquake. (Once some American duck hunters shot an ordinary carabao in a San Pedro rice field, and there was a "big row.")

Makiling, Leaning Mountain, the people of San Pedro and of other villages in Laguna Province consider a god, "in poetic language" as José the modernist puts it, *batala.* Of this mountain *batala* the people are descendants. Flood is punishment from Makiling, and once when there was a waterspout, a rare phenomenon, José saw people kneeling in prayer to the Mountain. A small group of people never converted to Christianity are said to live on the Mountain, subsisting on wild rice and wild pig. To kindle their cook fire they blow through a bamboo. Part of the San Pedro folklore about these people, derisive lore, is that to render men continent a woman will

[24] Of the village beggar, one Mariano, they say half humorously that Tikbálan has entered into him.

take a stick to the penis in erection. What don't we say about people we do not know!

Sakai, war leader and culture hero, has been powerful by virtue of his *anting anting*. An *anting anting* is an object of stone or wood which imparts invulnerability, invisibility and the power to transform into an animal of any kind, into bird or snake. Of course José had never seen an *anting anting*, no child has seen one and few adults, but José believes in them, just as he believed in the sacred bolo that hung on his father's wall. Because of its carved handle "God was in it." It was prayed to and "touched," like a saint.

Unlike bolo but like the miraculous ready-made image of Jesucristo of Landayang, an *anting anting* is just found. But unlike image and like bolo it is personal not ceremonial property. Diviners, *manghuhúla*, are possessed of *anting anting*. Perhaps Sakai was a sort of magnified *manghuhúla*.

The *manghuhúla* can foretell not only war but drought or storm, the coming of locusts, the coming of the fearful Bwaiya. He can locate for you a stray rooster or the carabao who does not answer to call or horn, or a daughter who has eloped. A woman will consult him to find out about her husband; married couples, to learn how many children they are to have. A *manghuhúla* diviner lives in the barrio of Kuyab and another in San Antonio.

Ordinary people may divine through dreams, dreaming winning numbers in card playing or in policy. Three and eight are popular numbers. A cockfighter who would divine will listen to cockcrows at dawn. If a cock crows three times under his house, he will bet on his cock, borrowing money from all his relatives, at the next regular Sunday afternoon cockfight, if not at the fight on January 6, "Three Kings" day, or at the big fight for which the patron saint's fiesta is famous. How carefully he has groomed his rooster, rubbing its comb, spraying water or puffing smoke on it, all to make it a valiant bird!

There are many gaps in José's story, but it fills out some of the gaps in our knowledge of Tagalog society, the least studied of Filipino cultures because considered to be the least Filipino. How much Spanish culture prevailed in San Pedro and still prevails, how much it is being encroached upon in language, in manners, in religion or in government through such American factors as railroad, school or Protestantism, students of acculturation may well take note. In the ancient golden age, before the Spaniards, José asserts, "everything was easy to get; people lived well; no *mangagawai*, no sickness; nobody took advantage of a woman or of an enemy." Why, then, in other connections does José use the term *kanunuung*, the grandparents' way, as a derogatory, almost insulting, term? Perhaps José's story will suggest study of a number of things.

EXTRA-SENSORY PERCEPTION: A REVIEW

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THE question whether extra-sensory perception occurs may be stated more precisely as follows: *Is it possible for a person to perceive (or respond to) objects or events without dependence upon the recognized senses?* The name, extra-sensory perception (ESP), covers the essential meaning of a wide variety of terms: telepathy, thought-transference, mind reading, clairvoyance, telesthesia, and cryptesthesia—to mention only the more common ones. But it is free from the special explanatory hypotheses and associations which some of the other terms have acquired.

The problem of determining whether ESP occurs is important at this stage in the history of psychology not because of practical interest in the possibility of extending the range of human perception—important though that may be. It is important primarily because the scientific world has settled down to the assumption that this extra-sensory class of phenomena does not occur, that it is, on a priori grounds, impossible. The trend of scientific thought regarding the relation between mental processes and the physical world has, since the days of Aristotle, followed the lead attributed to that philosopher himself: "Nihil est in intellectu quin prius feurit in sensu." To find, therefore, ever so slight an exception to this sensorial-physical conception would presumably have the same revolutionary consequences for modern psychology that the discovery of ever so small an exception to Aristotelian astronomy had for that science in the days of Galileo. The observation of the moons of Jupiter had no need to be practically important (nor their nature understood) in order to turn the world about.

The question of the occurrence of ESP has arisen from the frequently reported ("psychic") experiences of persons of all races and periods, experiences in which there is represented awareness of events under circumstances that would appear to exclude sensory perception. The more familiar of these spontaneous experiences consist of veridical dreams; hallucination-like awareness of distant scenes in the waking state, such as Swedenborg's reported vision of the Stockholm fire; apparent monitions of danger, such as those reported as occurring to Socrates; coincidental experience of the same pattern of thought by two separated persons. The reports of such phenomena and the attendant circumstances must either be wholly discredited or else they remain a challenge to the psychologist. Historically, then, it is out of these recurrent human experiences that the persistent question has emerged whether there may not be an extra-sensory mode of apprehending reality.

HISTORY

Throughout most of the cultural history of the race, belief in an extra-sensory order of perception was based upon such spontaneous experiences. They have been almost universally taken as a sufficient basis for the assumption of supernatural powers among religious groups and extended powers of perception have been attributed in most of the known religions, not only to divinities and spirits, but to religious leaders, prophets and sometimes to the ordinary layman in moments of special religious significance. Many philosophers, too, from Plato to Hegel, have simply assumed the occurrence of extra-sensory perception, with

no other support than that of the anecdotal evidence.

Among disciplines more accustomed to observation, at least of the "clinical" or "field" type, these spontaneous experiences have been noted and reported as incidental data. Psychic research societies have collected them for study. Anthropologists have placed on record the experiences and demonstrations of primitive people that appeared to represent extra-sensory perception. Medical men through the long history of Mesmerism and hypnotism found many occurrences of the type under discussion. Psychiatrists (Freud, Jung, Stekel and Janet) have encountered the phenomenon in an incidental way in the clinic. But while these secondary observations have served to keep the question open, they have added little, if anything, to the evidence upon which the answer must be based.

The direct experimental investigation of the occurrence of ESP has extended over a period of about sixty years, having begun with the formation of the Society for Psychical Research in England in 1882. Since that time, there have been 145 reports of systematic investigations of this kind, totalling 4,918,196 trials.[1] This great mass of test results represents the work of a wide variety of types of investigators and the use of a wide range of methods of testing. Of the 145 reports issued, 61 were by psychologists, 39 by other academic men, 18 by nonacademic professional men and 24 by laymen. The great majority of the reports written by psychologists have appeared during the last six years. The conditions and methods represented in these reports vary so widely, however, that there is no point to a discussion of their results as a whole. While in the main (to the extent of 73 per cent. of the total number of reports) the authors were led to the conclusion that extrasensory perception occurred in their experiments, it is only upon a closer analysis of results in terms of experimental conditions that any final judgment can be reached as to the present status of the ESP hypothesis.

Criteria

Before it can be determined how crucially the test results bear upon the question of ESP, it is necessary (1) to formulate still more precisely what that question is, (2) to describe at least in a general way the common test procedures used to investigate it, (3) to consider what alternative or counter-hypotheses might conceivably be applicable to the results obtained with such test procedures, and (4) to consider what criteria are demanded for a conclusion.

Formulation. The question of the occurrence of extra-sensory perception as clarified for the simplest conceivable experimental attack is stated as follows: *Is it possible repeatedly to obtain results that are statistically significant when subjects are tested for knowledge of (or reaction to) external stimuli (unknown and uninferable to the subject) under conditions that certainly exclude the use of the recognized sensory processes?* This statement of the problem is intended to avoid all assumptions as to the nature of ESP, its distribution among the general population, its psychological character or the regularity of its function. For example, it is not assumed that every one or any given person has ESP ability or that those who may show it on one occasion will necessarily do so on all test occasions. It is not assumed that it is a conscious process and that therefore a subject would be able to discover deception practised upon him by the experimenter. Finally, although it is essential

[1] These and other figures in this paper are taken from "Extra-Sensory Perception after Sixty Years," by J. G. Pratt, C. E. Stuart, Burke M. Smith and myself, of the Parapsychology Laboratory of Duke University, with the collaboration of Dr. J. A. Greenwood, of the Department of Mathematics of Duke University; published by Henry Holt and Company, New York, 1940.

to the testing of the ESP hypothesis that there be recurrence and repetition of ESP performance, it is not a part of this primary step to investigate whether it is invariably repeatable on demand by a given experimenter or under a given set of conditions. These and all other unnecessary assumptions are excluded at the start by the definition of the experimental problem.

Methods. In general the procedure required for the investigation of the ESP hypothesis would consist first of arranging for a specifically limited range of objects, symbols or other target material to be perceived. This restricted selection of objects is required by the need for statistical treatment, the only method which at this stage of investigation of ESP can solve the difficulty of determining what is due to chance and what may be attributed to other factors. So long as an uncontrollable or spontaneously occurring phenomenon is under investigation, there is no other way of appraising the test results than by statistics. (If the analogy of seventeenth century astronomy may be followed one step further, it could be said that the statistical method has been to the problem of ESP what the telescope was to extra-Aristotelian astronomy.) There has indeed been a considerable amount of work done in which no statistical evaluation could be made; that is, it was impossible to estimate what chance alone would have given. But such work commonly permits no very definite conclusion.

Given a fixed number of objects as a basis for the subject's perception, these objects must of course be completely removed from the range of sensory experience. If a deck of cards is used, as has most commonly been the case, the cards will of course be kept in the inverted position. A great deal of the earlier work was done with no further precaution than this. However, with greater concern about the validity of the conclusions, various ways of screening cards still more completely from sensory perception by the subject were introduced—methods such as enclosure in sealed opaque envelopes, the interposing of solid wooden screens or the separation of the cards and subject by placing them in different rooms.

The subject might be asked simply to call aloud what he thinks the symbol on a designated card is (for example, the top card on the deck), or he may be given materials for making his own record. A very common departure from these procedures (which are both designated as "*calling* methods") is the *matching* procedure for identifying the card or object. In this, the subject is given a deck of cards and requested to match them one by one against a set of key cards—the key cards consisting of the different suits of symbols represented in the deck. The matching might be done also by having the subject simply point to the key cards while the experimenter handles the deck of cards to be matched, or electrical keys may be introduced (one for each key card position) when the subject and the cards are separated by some distance. There are numerous modifications of both the calling and matching methods.

Viewed from another angle, there are two general types of ESP tests; namely, that in which an *objective* stimulus is to be perceived and that in which the *subjective* states of another person are to be apprehended. The first, or objective ESP test, is commonly called *clairvoyance* and the second, or subjective ESP test, *telepathy*. These two types of test may both be combined in a single test condition which may allow both for the direct apprehension of an object and of the mental experience of a person looking at or otherwise sensorially perceiving an object. These three general conditions might be designated as pure clairvoyance, pure telepathy and general ESP tests. Unless it is otherwise stated, the research to be discussed below will be of the pure clairvoyance type. This has

been mainly used because of the greater ease of obtaining conditions adequate to guard against sensory or other cues.

Counter-hypotheses. Before any experimental work could be said to establish the ESP hypothesis, there must be left no other conceivable hypothesis that could possibly explain the results. Not only must every other single conceivable hypothesis be excluded as inapplicable to the results, but all combinations of possible counter-hypotheses must likewise be shown inadequate to account for them. This is necessary in the introductory stage of every field of investigation ushering in a new principle. It requires a careful assembling of all conceivable alternatives in what would seem otherwise an unwarrantedly defensive manner. It is for the investigator himself, however, the only way of rigorously testing the interpretation and bearing of his results.

In the volume mentioned above, "Extra-Sensory Perception after Sixty Years," the authors list 35 counter-hypotheses which have to be shown to be inapplicable, taken singly and jointly, to the ESP experimental results as a whole. For brevity, however, it is possible to deal with these 35 hypotheses under 8 general headings as follows: Hypotheses (1) related to chance, (2) dealing with selection, (3) based on practices of the subject, (4) assuming shuffling defects, (5) dealing with errors in the records, (6) involving sensory leakage, (7) supposing incompetence on the part of the experimenter, and (8) concerning the general logic and conclusions of the research. To establish the ESP hypothesis by experiment, then, it is necessary so to design the experimental procedure that no habits or practices of the subject could consciously or unconsciously affect the conclusions; no card defects, recording errors, sensory leakage or other effect of experimental incompetence could enter into the production of favorable results. It is necessary to show likewise that no improper selection of data occurred. If the experimental procedure adequately guards against all these alternatives and the results are still unexplainable by chance, presumably the experiment has demonstrated extra-sensory perception in the sense defined and to the extent that the formulation of the problem was a proper one.

Amount of evidence. The further question arises, then, as to the finality of a single experimental study or, in other words, the question as to how much of independent repetition is required before the conclusion is established. This is a matter of individual judgment into which many factors enter, among them the degree of confidence in the general competence of the experimenters. Commonly in scientific matters which do not conflict with current conceptions, a few single independent repetitions are tantamount to full establishment. Probably for most students of the literature in extra-sensory perception likewise a few independent confirmatory reports from a psychological laboratory, based on conditions which meet all conceivable counter-hypotheses, would be adequate for establishment. There will, however, be many persons who will demand a large number of independent confirmations and the individual requirements will be various. There is no arbitrary criterion of judgment upon which to rely. For this reason "general scientific acceptance" is a very relative and uncertain matter.

Results

In turning now to the experimental results, it is necessary to confine attention to a relatively small portion of the total number of trials mentioned above. This is due largely to the fact that most of the 145 studies reported were made at stages of methodological development that are now greatly outmoded. Only work reported during the last six years meets the standards now followed as a basis for judgment, and even a considerable portion of that must be set aside as

suffering in some point from lack of necessary precautions. This is, of course, not to say that all or any of the work set aside may not constitute genuine instances of the operation of ESP; it is rather to say that it can not be regarded as crucial evidence of ESP as long as there is recognizable possibility of some one or other of the counter-hypotheses being applicable.

Sensory cues. By pruning out all results which were not obtained under conditions in which the objects (mostly cards) to be perceived extra-sensorially by the subject were not completely excluded from sensory contact of any kind during the test, and by excluding all blocks of data which can not be reliably evaluated (*e.g.*, radio test results), the 4,918,196 trials are reduced to 907,030. This summary represents the pooling of 30 different researches by 24 different authors and includes all work quantitatively evaluable that meets the standards laid down for preventing sensory leakage. The 907,030 trials gave an average score of 5.36 hits per 25 trials (in which 5 is the mean chance expectation). This means that there were 13,199 hits above the number expected by chance. This deviation is 39.9 times the standard deviation.* This last measure, the critical ratio,† is far beyond the usually accepted criterion of significance, a criterion which ranges from 2 to 3 among different groups of statisticians.[2] There are several other measures of statistical significance to which the data might be subjected and by which they are also significant. The various subdivisions of the results according to condition of screening (opaque envelopes, wooden screens, distance) are themselves highly significant; and of the 30 independent studies contributing these results, 24 gave significant total deviations under the conditions.

Recording errors. It is worth while also to consider the results of ESP tests made with a still further set of safeguards, those which were done with special measures taken against the possibility of recording errors. There has been, it is true, no discovery of significant results attributable to recording errors, even though considerable attention has been given to this subject during the last few years. Nevertheless recording errors do occur and it is of importance to know in what portion of the research just mentioned such errors could not have affected the conclusion even if they were made. If only those results are taken which were obtained under the condition of independent recording by different persons of cards and calls (or key cards), the number of trials is 220,455 and with this group the average score is 5.23, deviation 2,090 and the critical ratio 11.12. Again the subdivisions of the results according to ways of screening the cards from sensory leakage are each independently significant, and six of the ten individual studies are likewise.

Competence and trustworthiness. During recent years the intensive search for all possible alternative hypotheses has led some experimenters as well as critics to raise the question of the competence and even of the trustworthiness of the investigators. Unusual among scientific workers though this may be, it is a legitimate concern in a research that may have radical consequences to scientific thinking. This has led to a number of experiments being conducted especially to deal with the matter. There has been a total

* *Standard Deviation:* A unit of measurement in statistical method; that deviation above and below mean chance expectation which is expected to include about ⅔ the chance scores. For ESP cards, the theoretical standard deviation is approximately 2.04, no. of runs.

† *Critical Ratio* = C.R.: The observed deviation divided by the standard deviation.

[2] The methods of evaluation applied to the ESP data did, of course, not originate with the ESP research, but are taken from mathematical statistics. They have had the approval of mathematicians of probability, as expressed on various occasions, among the most authoritative being the statement of Dr. Burton H. Camp, president of the Institute of Mathematical Statistics.

of 72,750 trials made in which, along with all other precautions mentioned above, there were *two experimenters present at all times* during the experiments and the conditions were such that a mistake by one would have been detected by the other. These results give an average of 5.29, a deviation of 845 and a critical ratio of 7.82. Four of the six studies contributing to this total were individually significant.

Counter-hypotheses, jointly considered. There are other hypotheses that have to be weighed with the experimental findings, but they are of lesser importance and do not warrant space in this brief review. But there is a need to line up all the research which meets all the counter-hypotheses taken jointly, and to present it in condensed form. The most recently published work is, as might be expected, best fitted to meet the alternative hypotheses by specific measures taken. This is the work of Pratt and Woodruff of this (Duke) University. In this study, the additional provision was made for a written statement (made in advance) of the expected length of each experimental series. Upon submission of this statement to the record librarian of the Parapsychology Laboratory, in which Pratt and Woodruff worked, the experimenters were issued a requisite number of record sheets which were serially and identifiably numbered. This procedure insured against two variations of the selection-of-data hypothesis, one of these being the possible inadvertent loss of record sheets and the second that of the experimenter's optionally stopping the series at a point of advantage (that is, at a point at which the score average had reached a favorable level). Along with these safeguards went, of course, all the accumulated precautionary measures which had become a part of the test procedures. The 60,000 trials reported by Pratt and Woodruff were significant, having given a critical ratio of 4.99. (The average score was 5.20 and the deviation 489.)

While there is as yet in print only one study having the full precautions of the Pratt and Woodruff study (others are in manuscript), there are certain others which in effect meet the full range of counter-hypotheses, taken singly or together. Touching only briefly upon each instance, several of these might be mentioned here. First (also first in point of time, since it began in 1933), there is the Pearce-Pratt series conducted by two experimenters, Pratt and myself, with the subject, Pearce, in one building and the cards, handled by Pratt, in another. In a part of the series a distance of 100 yards separated the buildings used; and in the other part of the series, the distance between the buildings used was 250 yards. Duplicate records, independent checking, and other essential safeguards were introduced. In one series of 150 trials (average 9.3) the experimenters, Pratt and myself, were both present during each run. The results were highly significant, giving an average of 7.53 for 1850 trials and a critical ratio of 10.87.

A third case meeting all the requirements is that reported by Warner (formerly of New York University), consisting of 250 trials made with one subject at a single session. In this instance, the subject was in a separate room with a one-way signalling device by which she could communicate readiness for the next trial to the experimenters who were located on an upper floor in another part of the house (that is, not immediately overhead). There was a distance of about 35 to 40 feet between the subject and the position of the experimenter and his assistant. In this, as in the preceding instance, the subject made her own record while the experimenters recorded the cards. The call and card records were thus independently made, with two experimenters present throughout the experiment and the check-up. The average was 9.3 hits

per 25 trials, and the critical ratio was 6.8.

The fourth case to be mentioned is outstanding in several features, but particularly in its high score average. This is the study reported by Riess of Hunter College. The tests were made with a distance of more than a city block between the cards handled by the experimenter and the subject attempting to call them. Under these conditions in a series of 1,850 trials, the subject averaged 18.24 hits per 25, in one instance scoring a perfect run of 25 hits. There was not in this series the two-experimenter set-up that characterized those just reviewed, but to some extent the openly expressed critical attitude of Riess, together with his reluctance to associate himself with the field of ESP research by publishing his results would argue strongly against the supposition that the results obtained were the result of error motivated by the desire to prove the ESP hypothesis. The Riess tests were not of the more common pure clairvoyance type but were based upon what is called the general extra-sensory perception or GESP condition (that is, the experimenter looked at each card as the percipient was attempting to call it, thus allowing for both telepathy and clairvoyance).

The fifth study to meet all the requisites is a pure telepathy test series conducted with separation of the agent and the percipient (sender and receiver) by distances ranging from 165 to 300 miles. In this series, the experimenters were Miss Ownbey (now Mrs. George Zirkle, of Hanover College, Indiana) and myself. In a total of 650 trials, there was an average score per 25 trials of 6.8 and a critical ratio of 4.6, which is very significant. In this series the experimenter, Miss Ownbey, was trained to select the five symbols (circle, rectangle, plus, star and wavy lines) in random order—an order which would not be inferable nor patterned in any repeatable form. Various cross-checks in the data show that this goal was achieved and that the hypothesis of patterning does not apply either to the subject's calls or to the experimenter's selection. In this series one score of 19 and two of 16 were obtained. The records were made independently and were turned over at once to the second experimenter.

There are many other series which almost meet the full array of counter-hypotheses; for example, a study by Murphy and Taves, of Columbia University, that is thought to need certain recently suggested statistical corrections. The work of Martin and Stribic at the University of Colorado has not completely met all the latest requirements for safeguarding against errors of recording. The Pratt and Price study of this laboratory suffered only from the lack of permanent records of individual trials, the experimenters relying upon duplicate counting and independent recording of scores instead. These will illustrate what might be designated as the technically incomplete portion of the ESP research. In most instances the hypothetical technicality on which a series of experiments is ruled out is one which is not itself based on any real demonstration of error but rests upon a logical possibility.

Does ESP occur? Whether or not it may be concluded that ESP is a valid phenomenon in nature is necessarily a somewhat individual and relative matter. It will probably be agreed, however, that almost any other scientific hypothesis would, if supported by the amount of evidence that supports this one, be regarded as established. Certainly it may be said that unless or until some new counter-hypothesis is offered to give new issue to the interpretation of the present results, there is no very reasonable alternative to acceptance of the occurrence of ESP as established. Those who will find it difficult to take this position must, it would seem, have recourse either to a general rejection of scientific method or to a general faith

(always a possibility, of course, in any field) that some further alternative hypothesis will yet turn up. Some readers may simply have insufficient confidence in scientific method to accept, whatever the evidence, the occurrence of a phenomenon which they can not explain. For such as these time and further research developments will be needed for a final settlement of the question.

The Nature of ESP

Distribution. The first general question that arises regarding ESP, once it is accepted, is that of its distribution. What percentage of people possess such ability and what kind of people are they? The efforts to answer these questions have been in the main only incidental to the endeavor to investigate the existence of ESP. But investigators in different parts of the world have naturally worked with groups of a considerably wide geographic distribution, with some differences in race, age, sex, intelligence, sensory acuity, normality, and other characteristics, and the comparisons are available.

As to the percentage of persons capable of demonstrating ESP in tests, there is so much variation in test performance, due presumably in part to conditions under which the tests are taken, that estimates are of little value; and in any case statistical results do not permit rating of individual performance with anything more than a probability. The tentative estimates that have from time to time appeared—that roughly 20 per cent. of the population tested might be said to have shown ESP ability—can not be taken with any finality and would not be necessarily applicable to every group of subjects or experimenters. Precise information on distribution will have to wait for further enlightenment in the control of the ability requested.

It is, however, of considerable value to have the elemental facts that successful performances in ESP tests have been reported from different countries, and that a variety of groups and classifications of people have been tested, with the general result that no outstanding group differences have been found. While the investigator is usually hopeful of being able to associate ESP ability with some biological, anthropological, or personality characteristic, it has not yet appeared that there is any such association. Both normal and abnormal subjects have been successful, as well as both blind and seeing, highly intelligent and subnormal, young and old, male and female, hypnotizable and non-hypnotizable, hypothyroid and hyperthyroid.

All this suggests that the ability is not a superficial acquisition, not an odd and isolated development, but something which is perhaps a deeply imbedded property of the personality in all its diversified forms. This, however, is nothing more than a suggestion.

Conditions that influence ESP. Turning to the conditions that affect performance in ESP tests, determining success or failure, quite a different picture is found. Here are at least many definite findings, though some of them must be taken with reservation because there are always, in experiments with human subjects, many conditions within the subject's own personality that can not be either evaluated or controlled.

It is demonstrated that the conditions of the experiment in general affect performance. First, physical conditions of the subject; second, conditions of motivation; third, cognitive differences in the test; fourth, perhaps overlapping with the second, the social situation of the tests; and fifth, the test procedures themselves appear to have some effect.

As an example of the effect of physical conditions of the subject upon performance, it is indicated that large doses of a narcotic drug, sodium amytal, one that greatly hinders general mental functioning, adversely affects ESP performance and is counteracted by caffeine—which physiologically counteracts the dissocia-

tive effect of the narcotic. In the realm of motivation, it is likewise indicated that rewards, competition, novelty of test material and other conditions tending to arouse interest in the task seem to help performance; whereas making the test run unduly long, withholding information regarding scores when the subject wants to know them, and otherwise frustrating the interest of the subject tends to lower the score.

There is sufficient data to suggest that there is a considerable cognitive value to the limitation of the range of choices in a test to the neighborhood of 5; that is, if more than 5 suits or types of symbol or object to be guessed are used, there appears to be a decline of efficiency obtained, as is likewise true going in the other direction and using a smaller number than 5. Trance, either hypnotic or self-induced, seems to be as yet of no demonstrated effect.

There is evidence, too, to indicate that the personal relations between subjects and experimenters are determinative of success. Some experimenters evoke favorable working relations and others fail to do so. The presence of visitors or the conduct of the tests with subjects in groups have in general given much lower scores than with the individual subject working in relative isolation.

While the calling and matching procedures are approximately equally successful, certain modifications of both of these have proved in general less favorable to high scoring. For example, in the calling procedure if the cards are not removed from the deck one at a time and the trials thus separately indicated, there is apparently a loss of efficiency. In the matching procedure, if the key cards are inverted, the results are generally lower than if they are exposed—even when the deck to be matched is itself completely screened from view in both procedures.

Physical relations. No physical characteristic of ESP has as yet been discovered nor even a suggestion that there is such. The one outstanding feature that runs through the sixty years of ESP experiments is the sharp departure of ESP test results from what would be expected if known physical processes were responsible. There is available in present physical knowledge no hypothetical intermediating energy linkage between stimulus and percipient that meets all of the conditions under which ESP has been found to occur. These conditions can only be outlined in the present space. No one of the single findings in itself warrants the view just expressed regarding the inapplicability of physical law to ESP results; this is rather a reflection of the total picture presented.

There is first the absence to date of any physical condition of the stimulus found to be inhibitory in ESP tests. Sizes, shapes, angles, concealment or enclosure of the stimulus object do not prevent effective ESP performance. Objects may be superimposed upon each other, as in the test of calling "down through" a pack of cards, in the close proximity of 100 to the inch. They may be separated from the percipient by distances of hundreds of miles with intervening terrain of mountainous character. Subject and object may occupy positions with respect to each other involving various angles. The physical nature of the stimulus itself may vary widely. It may even have no known physical constitution, as for instance in the pure telepathy tests in which the subjective state of another person is apprehended. All together, these findings require either a physical process that is considerably unlike anything that is known to-day or else a process that is extra-physical. But perhaps such a distinction at this stage is not very meaningful.

Psychological relations. It may be stated with certainty that considered as a psychological activity the process of extra-sensory perception is entirely unconscious and has rendered little or

nothing that is fruitful through the methods of introspection. In its performance it has been generally erratic and as an ability it appears highly unstable. There is no adequate evidence as yet of its development through use, and although it is subject to voluntary control to a certain extent—namely, to the extent of directing it toward given objects and toward either hitting or missing—this control may be regarded as largely the direction of application or utilization. The immediate activation of the process is apparently spontaneous and involuntary; that is, the subject can not from moment to moment say whether he is going to perceive extrasensorially or not; any more than he can with certainty tell in retrospect whether he has done so or not.

ESP, too, is a "diametric function"; when two cards are to be matched, neither one of which is known, it has been shown that the mind takes a short cut—that is, it does not first identify one and then the other and then decide they are alike or unlike. It seems to decide simply that they are alike or unlike as a unitary act. This is called (by Foster) "diametric" because it cuts across, as it were, instead of going around to arrive at the final judgment step by step.

Finally extra-sensory perception and sensory perception appear to be much alike except in the relation of the subject to the stimulus. When sensory perception is tested at a low level of stimulus intensity which makes the process more comparable to ESP, there is indication that it is subject to some of the influences now known to affect ESP performance. More investigation of this important line of comparison is needed and is being undertaken. On the other hand, when compared as to the relation of the percipient to the stimulus object, there is a vast difference. ESP is responsive to an enormously wider range of stimuli and of conditions of stimuli than any known sense modality; it is independent of bodily orientation to the stimulus; it does not permit introspective localization of reception; and it functions under conditions for which no known stimulating energy could intermediate. A question arises then in the psychology of ESP (comparable to the final question on the physics of ESP) as to what this apparent lack of stimulation means in the general view of the relation of the ESP subject to his environment. Is it a question here of perception without mechanical intermediation? Or is there an energetic determinant of the ESP results that escapes the classification and criteria now embraced by the curricular physics of the moment?

Again it may be that the distinction implied by these alternatives is less important than has been hitherto thought —conceptions of "physicality" may change and may at best be mere academic boundaries; nevertheless it is our *present* knowledge (not that of the future) by which we must be guided, and according to this, whatever its worth and its permanency, there is a marked dichotomy between the workings attributed to ESP and those of the sensory-mechanical world with which science has hitherto had its main dealings.

How far such a break with orthodoxy is justified calls for the greatest caution in the determining; for if the step is a fully warranted one, the scientific reconstruction that must follow is probably far beyond present-day capacity to realize. But by this very eccentricity of the consequences of the ESP hypothesis may be measured roughly the shift of center and the resultant shift of scientific perspective of the universe which logically must follow in the fullness of time and with continued research. What has been found thus far is something to be explained, and later incorporated, in a much enlarged world of knowledge, more than it is a step in enlightenment itself. The investigation has been opened instead of closed.

JOSEPH CONRAD AS A GEOGRAPHER

By FLORENCE CLEMENS

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THE whole commercial world looks with increasing interest toward the far-flung Malaysian isles. Since early times, when European nations fought for the spice trade in that remote and vaguely charted archipelago, until to-day, when practically every particle of it is "protected" by some non-Asiatic country, those rich and desirable islands have exerted their magnetic influence. The energetic, ambitious white race continues to convert them from their original wilds into plantations and mines and trading centers, but vast portions remain difficult of penetration and yet unexplored, both enticing and repellent.

The geographical background of Joseph Conrad's Malaysian fiction has long excited critical interest. It has been praised as a wonderful harmonious accompaniment to his plots and to the moods of his characters. Editions of his books have been published containing maps, showing the main centers of his stories. With all this its importance has not yet been fully appreciated.

In spite of its vividness and charm, Conrad's picture of Malaysia is, of course, subordinated to his chief purposes. This strange, remote scene isolates his characters and situations, cutting them off from their ordinary backgrounds and so concentrating an intense light upon them. They become laboratory specimens, segregated for microscopical examination. It is this peculiar method which makes the reading of one of Conrad's Eastern novels a breathtaking experience. Lay aside the plot, however, and there remains a body of literature which should fill the heart of any true geographer with delight.

It will be remembered that Joseph Conrad's experience in the East was confined to that of a seaman. For a decade, from 1878 to 1888, he saw much of the region as sailor, second or first mate, and finally as captain. Naturally he visited coastal parts and sections up the rivers which led to trading towns. Of the *far* interiors he saw nothing, nor does he seem to have gone much beyond the ordinary routes of his boats. No one writing of the Indies, however, has possessed a more sensitive and receptive mind, a mind of more photographic accuracy.

Conrad first saw Malaysia sixty years ago, but much that he wrote is as true to-day as it was then. Conceded that he by nature had a strong sense of actuality, his training for the sea undoubtedly strengthened his power of direct, exact observation. His memory, too, was very tenacious, and these powers, augmented by his wonderful expressiveness, have resulted in the valuable record of the Malaysian scene included in his fiction. No one should be misled into feeling that Conrad's Malaysia is fictitious because of the stories. As captain he was obliged to follow charts with perfect precision. It became habitual with him to be true to exact geographical positions in his writing, also. Perhaps his experience would have led him to feel guilty about being otherwise. Altogether he used about one hundred place names, and nearly all of them can be found by searching the maps.

Conrad wrote five novels and twelve short stories, placed somewhere in that part of the East which includes southeastern Asia and the island world between it and Australia. "Malaysia" is an elastic term, usually restricted to the East Indies and the Malay Peninsula,

the supposed home of the true Malay, but sometimes extended into a wide territory in which lie the settings of all Conrad's Eastern fiction—from Mauritius in the west to the Solomon Islands in the east. A study of the fiction produces a true impression of the general topography of this area as well as innumerable clear-cut close views. We become acquainted with "the shallow sea that foams and murmurs on the shores of the thousand islands, big and little, which make up the Malay Archipelago."[1] We are shown the contrasting barrenness, fertility and rank wilderness which the islands have to offer. "Out of the level blue of the shallow sea Carimata raises a lofty barrenness of grey and yellow tints, the drab eminence of its arid heights. Separated by a narrow strip of water, Suroeton, to the west, shows a curved and ridged outline resembling the backbone of a stooping giant."[2] These sterile bits of land are quite unlike Bali's "terraced fields . . . (and) murmuring clear rills of sparkling water that flow . . . down the sides of great mountains bringing life to the land and joy to its tillers,"[3] or the jungles, the "luxuriant vegetation bathed in the warm air charged with strong and harsh perfumes, the intense work of tropical nature . . . , plants shooting upward, entwined, interlaced in inextricable confusion, climbing madly and brutally over each other in the terrible silence of a desperate struggle towards the life-giving sunshine above—as if struck with a sudden horror at the seething mass of corruption below, at the death and decay from which they sprang."[4]

This fiction should be read with atlases and geographies at hand. They prove that Conrad may be trusted as a geographer. For example, consider his description of the lower Meinam River as compared with those of geographers. Conrad became acquainted with it when he went to Bangkok in 1888 to take charge of the *Otago*. Elisée Reclus in his "Asia" describes the basin of the Meinam (variously spelled, as practically all native words used as geographical names in Malaysia are) as follows:

> Although less extensive than the other great Indo-Chinese fluvial basins, that of the Menam, or "Mother of Waters," occupies a more central position, and has thus played a leading part in the historic evolution of Farther India. Uniting its waters with several other rivers in a common delta, it reaches the coast at the northern extremity of a gulf, which penetrates far inland, and which presents a seaboard of no less than 900 miles. The entrance of the Menam thus forms the central point of a vast circle, towards which converge all the sea routes on the one hand, and on the other all the highways of the river valleys. . . . The Menam rises in the Lao territory and throughout the whole of Siam proper is navigable by light craft, while steamers ascend its lower course with the tides. . . . At the head of the gulf a crescent of submerged sandbanks, stretching some 60 miles east and west and accessible to vessels of 500 tons only at high water, separates the sea from the plains of Bangkok, which at one time formed a northern continuation of the gulf.[5]

In "The International Geography," edited by Hugh Mills, are these sentences:

> The heat of the great alluvial plain is tempered by its proximity to the gulf. . . . The amount of moisture in the atmosphere, however, makes the climate of the lowlands peculiarly trying.[6]

Ernest Young's travel book, "Siam," offers this description of the river:

> Siam has only one great river that is entirely her own. It is marked on English maps as the "Menam," but the real name is "Menam Chow Phya." . . . The Menam is not merely the mother of the waters, but of the land also, for all the lower part of Siam is one extensive plain, which has been built up by the mud, gravel, and

1 "The Rescue," p. 3.
2 *Ibid.*, p. 5.
3 "Almayer's Folly," p. 174.
4 *Ibid.*, p. 71.

5 New York: D. Appleton and Company, 1895, Vol. 3, pp. 458–459.
6 New York: D. Appleton and Company, 1900, p. 509.

sand brought down from the mountains by the river.

Suppose we get on board a steamer and sail from Bangkok down to the mouth of the Menam. The distance from Bangkok to the mouth of the river, measured as the crow flies, is only twelve miles, but so much does the river twist and turn that we shall be three hours before we reach the sea. . . .

By this time we are at the mouth of the river. Here the current of the river meets the sea. That current is bearing with it tons of fine sand and soil. But the sea seems to say to the river, "Thus far, and no farther." And so here all the muddy stuff in the river water is deposited. In this way a bar has been formed, which blocks the river mouth. At low tide there are only three feet of water over it, and even during the highest tides there is never more than fifteen feet of water on the bar. Hence very large steamers can never enter the Chow Phye, but have to load and unload their cargoes by means . . . of lighters.

The chief attraction at the mouth of the river is a magnificent pagoda known as "the Shrine in the Middle of the Waters." It stands on a little island, is built of whitewashed stone and bricks, and is surrounded by the buildings of the temple of which it forms a part.[7]

On page 468 of Reclus, "Asia" is a map of the Meinam from Bangkok to the gulf. The line of the river executes great looping meanders between the city and the mouth. Midstream on the last big curve is the island with the pagoda, marked "Pahnam." The depth of the water at the mouth of the river is given. The mid-channel measures only three to sixteen feet, and the extensive mud bars indicate how difficult navigation is. The coast is shown as very low.

Now, how does Conrad describe the river? A series of quotations will tell:

There were no pilots, no beacons, no buoys of any sort; but there was a very devil of a current for anybody to see, no end of shoal places, and at least two obviously awkward turns of the channel between me and the sea.[8]

There was a shallow bar at the mouth of the river which ought to have been kept down, but the authorities of the State were piously gilding afresh the great Buddhist Pagoda just then, and had no money to spare for dredging operations. I don't know how it may be now, but at the time I speak of that sandbank was a great nuisance to the shipping. One of its consequences was that vessels of a certain draught of water, like Hermann's and mine, could not complete their loading in the river. After taking in as much as possible of their cargo, they had to go outside to fill up. The whole procedure was an unmitigated bore. When you thought you had as much on board as your ship could carry safely over the bar, you went and gave notice to your agents.[9]

I could not detect the smallest dot of a bird on the immense sky, and the flatness of the land continued the flatness of the sea to the naked line of the horizon.[10]

Eighteen miles down the river you had to go behind him, and then three more along the coast to where a group of uninhabited rocky islets enclosed a sheltered anchorage. . . . There was nothing to look at besides but a bare coast, the muddy edge of the brown plain with the sinuosoties of the river you had left, traced in dull green, and the Great Pagoda uprising lonely and massive with shining curves and pinnacles like a gorgeous and stony efflorescence of tropical rocks.[11]

And when I turned my head to take a parting glance at the tug which had just left us anchored outside the bar, I saw the straight line of the flat shore joined to the stable sea, edge to edge, with a perfect and unmarked closeness, in one levelled floor half brown, half blue under the enormous dome of the sky. . . . Two small clumps of trees, one on each side of the only fault in the impeccable joint, marked the mouth of the river Menam we had just left on the first preparatory stage of our homeward journey; and, far back on the inland level, a larger and loftier mass, the grove surrounding the great Paknam pagoda, was the only thing on which the eye could rest from the vain task of exploring the monotonous sweep of the horizon. Here and there gleams as of a few scattered pieces of silver marked the windings of the great river; and on the nearest of them, just within the bar, the tug steaming right into the land became lost to my sight.[12]

One morning early, we crossed the bar, and while the sun was rising splendidly over the flat spaces of the land we steamed up the innumerable bends, passed under the shadow of the

[7] London: Adam and Charles Black, 1910, pp. 10–14.

[8] "Falk," Selected Stories of Joseph Conrad, p. 189, New York: Doubleday, Doran, 1930.

[9] *Ibid.*, pp. 164–165.

[10] *Ibid.*, p. 209.

[11] *Ibid.*, pp. 165–166.

[12] "The Secret Sharer," "Twixt Land and Sea," p. 91.

great gilt pagoda, and reached the outskirts of the town.[13]

About mid-day we anchored a mile outside the bar. . . . While watching the work from the poop. . . . I detected in it some of the languor of the six weeks spent in the steaming heat of the river.[14]

I believe he had partly fretted himself into that illness; the climate did the rest with the swiftness of an invisible monster ambushed in the air, in the water, in the mud of the river bank.[15]

Thus in his portrayal of the Menam River, of Pahnam Pagoda and of the scene at the mouth of the river, Conrad presented an authentic picture.

It is a fascinating game to compare Conrad's geography throughout in the same way with whatever can be found in reliable geographies and travel books. With vivid truthfulness "The Shadow Line," "Falk" and "The Secret Sharer" present Bangkok and the lonely areas of the east Siamese gulf. The setting of "Freya of the Seven Isles" lies in a thick group of tiny islets directly south of the Malay Peninsula and within sight of the low swampy coast line of east Sumatra. They are forest-covered hills, well drained and healthful and, so, very different from the pestilential coast toward the west. Nelson's island of the story is true to the actual geographical character of that section.

Conrad visited Singapore a number of times. He took a home-going boat from the city in 1881, after he had escaped from the burning *Palestine,* which sank west of Java. He was there again in 1885, and in 1887 he was in the Singapore hospital for three weeks, recovering from an injury received while he was on the *Highland Forest.* During the period while he was making the important Bornean trips as mate on the *Vidar,* he was in Singapore, the starting point of the route, five or six times. "The End of the Tether" contains an example of Conrad's passion for accuracy. A comparison of the Singapore of the story with a chart of Singapore included in "Federated Malay Railways," an official booklet of 1914, shows that he placed the Esplanade, St. Andrew's Cathedral, the Government House, the library, the harbor obelisk, etc., with great exactness. He even stated that it was three miles by tramway from the library to the New Harbour Docks (The name had been changed to Keppel Harbour by 1914, as the booklet explains), and the scale provided for measuring distances on the map justifies that statement.

Home-going voyages took him through the Straits of Malacca. The geographical variety to be found along its shores is compressed with great precision, judging from authoritative descriptions, into the background of "The End of the Tether." Captain Whalley's points of trade are on the charts—Low Cape, Batu Beru and Melantan on the Sumatran coast, and Malacca, Pangu and Tenasserim on the mainland. There is extreme contrast between the low-lying Sumatran shore on the west and the rocky islands to the north. To quote from the story:

From Low Cape to Malantan the distance was fifty miles, six hours' steaming for the old ship with the tide, or seven against. Then you steered straight for the land, and by and by three palms would appear on the sky, tall and slim, and with their dishevelled heads in a bunch, as if in confidential criticism of the dark mangroves. The *Sofala* would be headed towards the sombre strip of the coast, which at a given moment, as the ship closed with it obliquely, would show several clean shining fractures—the brimful estuary of a river. Then on through a brown liquid, three parts water and one part black earth, on and on between low shores, three parts black earth and one part brackish water, the *Sofala* would plough her way upstream.[16]

So is the Sumatran coast, a very different place from the section of clear

[13] "The Shadow Line," p. 47.

[14] *Ibid.,* p. 73.

[15] *Ibid.,* p. 67.

[16] "Selected Stories of Joseph Conrad," p. 165.

waters and rocky reefs not many miles north, which, according to Reclus, are inhabited by "rude fishing communities of the Silongs who encamp during the south-west monsoon on the Mergui Islands, and at other times reside chiefly in their boats or on the beach."[17] Conrad wrote of it:

They had just left a place of call on the mainland called Pangu; they were steaming straight out of the bay. . . . Across the wide opening the nearest of a group of small islands stood enveloped in the hazy yellow light of a breezy sunrise; still farther out the hummocky tops of other islets peeped out motionless above the water of the channels between, scoured tumultuously by the breeze. The usual track of the *Sofala* both going and returning on every trip led her for a few miles along this reef-infested region. She followed a broad lane of water, dropping astern, one after another, these crumbs of the earth's crust resembling a squadron of dismasted hulks run in disorder upon a foul ground of rocks and shoals. Some of these fragments of land appeared, indeed, no bigger than a stranded ship; others, quite flat, lay awash like anchored rafts, like ponderous, black rafts of stone; several, heavily timbered and round at the base, emerged in squat domes of deep green foliage that shuddered darkly all over to the flying touch of cloud shadows driven by the sudden gusts of the squally season. . . . The multitudes of seafowl urging their way from all the points of the horizon to sleep on the outer rocks of the group, unrolled the converging evolutions of their flight in long, sombre streamers upon the glow of the sky. The palpitating cloud of their wings soared and stopped over the pinnacles of the rocks, over the rocks slender like spires, squat like ruins, over the lines of bald shoulders showing like a wall of stones, battered to pieces and scorched by lightening—with the sleepy, clear glimmer of water in every breach. The noise of their continuous screaming filled the air. . . . But when the *Sofala* happened to close with the land after sunset she would find everything very still there under the mantle of the night. . . . Sometimes there were human eyes open to watch them come nearer, travelling smoothly in the sombre void; the eyes of a naked fisherman in his canoe floating over a reef. . . . A few miserable, half-naked families, a sort of outcast tribe of long-haired, lean, and wild-eyed people, strove for their living in this lonely wilderness of islets, lying like an abandoned outwork of the land at the gates of the bay. Within the knots and loops of the rocks the water rested more transparent than crystal under their crooked and leaky canoes, scooped out of the trunk of a tree.[18]

Conrad acquired his most important experience in the East on the *Vidar* in 1887 and 1888. Each trip required three weeks, and he made five or six in all. The *Vidar* rounded the west, south and east coasts of Borneo and touched ports in west Celebes. Out of these trips grew the background scenes for the three novels concerning Tom Lingard and for several short stories. From these great books Borneo emerges so real that one can not read and escape the sensation of having seen that enormous, thick, dark, continent-like island with its smooth, dangerous coast line and its mangrove and atap-palm-lined muddy rivers, nor without knowing the intense heat and fearful beauty of its hot jungles and swamps. The descriptive books bear out every detail which Conrad attributes to Borneo, but none of them leaves his overwhelming impression of actuality. Thus, for an example in detail, German writes in his "Handbook of British Malaya" that there the frequency of thunderstorms is probably the highest in the world, but it takes Conrad's pages to impress us with the quality of such thunderstorms.

A light frown ran over the river, the clouds stirred slowly, changing their aspect but not their place, as if they had turned ponderously over; and when the sudden movement had died out in a quickened tremor of the slenderest twigs, there was a short period of formidable immobility above and below, during which the voice of thunder was heard, speaking in a sustained, emphatic and vibrating roll, with violent louder bursts of crashing sound, like a wrathful and threatening discourse of an angry god. For a moment it died out, and then another gust of wind passed, driving before it a white mist which filled the space with a cloud of water-dust that hid suddenly from Willems the canoe, the forests, the river itself. . . . He made a few hurried steps up the courtyard and was arrested by an immense sheet of water that fell all at

[17] "Asia," p. 491.

[18] "The End of the Tether," "Selected Stories of Joseph Conrad," pp. 241–244.

once on him, fell sudden and overwhelming from the clouds, cutting his respiration, streaming over his head, clinging to him, running down his body, off his arms, off his legs. He stood gasping while the water beat him in a vertical downpour, drove on him slanting in squalls, and he felt the drops striking him from above, from everywhere. . . . From under his feet a great vapour of broken water floated up, he felt the ground become soft—melt under him—and saw the water spring out from the dry earth to meet the water that fell from the sombre heaven.[19]

Conrad has left us our finest existing description of a tropical lagoon ("The Lagoon"). Whoever wishes to know the out-of-the-way Tiger Islands should read "Victory." "Karain," "The Rescue" and "Lord Jim" take us directly to south Celebes. The most far-flung situations in the fiction are two islands: mountainous Mauritius near Madagascar of "A Smile of Fortune," and Malata of "The Planter of Malata," as far east as to feel the refreshing Pacific breezes. Nowhere in all that area was a flagrant geographical error made.

To be sure, Conrad sometimes used his artist's right to build his own scene, but he constructed only of native materials gathered together and redistributed with wholly natural effect. Thus, as far as we know, he never visited the west coast of Sumatra, an important scene in "Lord Jim." He placed Patusan very exactly up a river Patusan, which entered the ocean one hundred miles south of a headland so described that it must have been Atjeh. At that place there is no Patusan but, instead, the Tenom River, which Conrad's descriptions fit perfectly. A long search places the name "Patusan" in Borneo up the Batang Lupar River. This Patusan was famous in the days of the first Rajah Brooke as a pirate resort, where two Arab brothers occupied a hill fortress like the one held by the pirate Arabs of the Patusan of "Lord Jim." Sir James Brooke's diaries were a quarry from which Conrad mined bits of plot, character and situation for his novels. Patusan is true to the Sumatran scene, but the ghost of Borneo haunts it.

Alfred Wallace's "The Malay Archipelago" even more than Brooke's diaries influenced Conrad's fiction. Wallace was so trustworthy a source that Conrad never hesitated to consult him when he left the territories of his own experience. The Bali of "Almayer's Folly," the Timor of "Victory" and the east Celebes of various stories come from "The Malay Archipelago," but they are accurate because Wallace was accurate. Never would Stein of "Lord Jim" have told his wonderful story of capturing a Celebes butterfly if Wallace had not actually caught the original of that same gorgeous creature years before.

A century ago, Malaysia was nearly as inaccessible as the moon to the majority of Westerners, but the last fifty years have added much to our knowledge of it. New books appear annually about it, and parts of it have become well-advertised tourist resorts. General interest in the archipelago grows. It is not probable, however, that another writer of the caliber of Joseph Conrad soon will record its fascinating contours for us. His Eastern fiction will remain one of the permanent literary contributions about that particular section of the globe.

[19] "An Outcast of the Islands," pp. 282–283.

SCANDINAVIA'S FUEL PROBLEM

By Dr. W. H. VOSKUIL

MINERAL ECONOMIST, ILLINOIS STATE GEOLOGICAL SURVEY

THE Scandinavian economy is founded essentially upon the production for the world market of commodities of high exchange value and of relatively small bulk. This is true, in a large measure, of both agricultural and industrial economics. In Denmark, the low-lying, highly cultivated plain produces mainly grain, potatoes and sugar beets. Dairying is extensive and, under peacetime conditions, butter, cheese, pork and pork products are exported, as well as manufactured products of wood, metals and textiles. The food supply is augmented by large coastal fisheries.

In Norway, the preponderance of forested areas supports extensive lumbering, pulp and paper industries. Hydroelectric power supports electrochemical and electrometallurgical industries having as their products fixed nitrogen for agriculture, steel alloying materials (ferro-chrome, ferro-manganese, ferro-silicon) for Europe's iron and steel centers, and aluminum. Sea fisheries (cod, herring, mackerel) and whaling supplement, in part, the meager agricultural resources of a land in which less than 3 per cent. is arable.

The Swedish economy is both larger and more diversified than that of either Norway or Denmark. The agricultural area is more extensive, forest resources are abundant, minerals exist in greater abundance and variety. The latter include copper, zinc, nickel, silver and coal, but most important is the Swedish iron, for centuries famous for its quality.

The forest products supply materials for extensive industries such as lumber, wood pulp and paper. Metal manufacturing is of a type rated for high quality and specialty production based upon the excellent iron ores and electrometallurgical products and an abundance of low-cost water power. Sweden has the largest known reserves of high-grade magnetite in the world. Upon this resource is built an industry of small tonnage and high quality, the products of which are widely in demand. Sweden is also an important producer of ferro-alloys, particularly ferro-silicon, silica-manganese, silica-spiegel and ferro-chrome. Cheap electrical power accounts for Sweden's position as a producer of ferro-alloys, since the industry is dependent upon imports of manganese, tungsten, chrome and vanadium.

With one exception, namely, fuels, the Scandinavian countries and Finland have diversified mineral resources adequate to establish and maintain industrial operations to a greater extent than is true at the present time. Despite an overabundance of high-grade iron ore, an exportable surplus of iron and copper pyrites and fairly adequate reserves of numerous other industrial minerals, this region is an excellent example of the adverse effect on industrial progress that is due to a lack of domestic reserves of high-grade coal and crude petroleum.

In spite of extensive water-power developments and also the use of wood as fuel, the Scandinavian nations imported each year approximately 16 million to 18 million tons of coal and coke and 20 million barrels of gasoline, kerosene, fuel oil and lubricants. In their foreign trade relations, these three countries have intimate ties with both Great Britain and Germany. For decades they have depended almost entirely upon Great Britain for a coal supply, and only in recent years have Poland and Germany

encroached upon this market. For the products of her farms, forests and metal works, competition among European consumers is keener than at any previous time in history. The United Kingdom has long been a profitable outlet for Danish butter, bacon, eggs and lard. Among the minerals, Germany is in most instances the principal buyer, especially of copper and its ores, feldspar, granite, iron ore and pyrites. The Scandinavian nations thus have found themselves bound by trade relations to both the allied powers and Germany, profiting most by freedom of trade among its European neighbors.

The commanding position of the British coal industry in the Scandinavian market was a natural consequence of tidewater location of collieries, supplying the overseas market, lower transportation costs and a well-organized coal export industry. That their market should yield to competition from the Polish East Upper Silesian mines is the result of a combination of circumstances arising out of the post-war consequences of the treaty of Versailles.

Before the war both East and West Upper Silesia were Germany territory, and these fields together supplied the bulk of the coal needs in the eastern districts of Germany with some export to Russian Poland. In the post-war readjustments, the East Upper Silesian field was awarded to Poland, with its annual output of 30 million tons or over. This transfer, in 1922, of this field to Poland left eastern Germany without adequate local coal supplies, whereas Poland controlled a productive capacity in excess of its own needs. Under an agreement of three years' duration and terminating in June, 1925, Germany agreed to take coal from Poland at a rate of 6 million tons a year. Shipments during 1923 and 1924, however, exceeded this amount, the actual quantities delivered being 8.4 million and 7.0 million, respectively. In the meantime, Germany increased its productive capacity in the West Upper Silesian field to compensate its losses in the eastern field. At the expiration of the agreement in June, 1925, production in Germany's own field had so expanded as to take care of the local domestic needs and the imports from Poland practically ceased. The net effect of this development was to expand the productive capacity of the entire Silesian area. With surplus mine capacity available, the Polish producers were compelled to seek outlets elsewhere. The prolonged strike of the British miners in 1926 opened the way for entry into the Scandinavian market. Exports to these countries increased from 0.5 million tons in 1925 to 5.4 million tons in 1928, and remained above 5.0 million tons through 1930.

By agreement between the United Kingdom and Sweden in 1933, 47 per cent. of the coal annually imported by Sweden is furnished by the United Kingdom. A similar agreement with Norway assured for the United Kingdom 70 per cent. of Norwegian imports.

German exports of coal to the Scandinavian countries, while considerably below the level of British and Polish coal shipments, nevertheless showed substantial gains in recent years. The principal form of fuel supplied by Germany was coke.

The profitable economic relationships of Scandinavia with its western European neighbors was rudely upset by the outbreak of hostilities among the major powers. The conquest of Poland interrupted this major source of coal supply and British shipments were hampered by the blockade of the Kattegat. Sweden, by reason of its land-locked position, was especially affected. The index of coal prices in Sweden (1913 = 100) rose from 128 in January, 1939 to 134 in August, 191 in September, 202 in October, 208 in November and 239 in

December, as against 125 in December, 1938.

The invasion of Norway, in April, 1940, extended and intensified an already critical condition with respect to fuel supplies. Occupation of Danish and Norwegian ports by the Germans severed the last connection of the Scandinavian nations with their customary sources of coal supply and left open to them only so much as the Germans are able and willing to supply, supplemented by meager shipments from the United States.[1]

Denmark, normally importing about 6 million tons of coal and coke, of which Germany supplied about 1 million, is turning in its predicament to peat moss as a supplementary fuel. Germany, with commitments of 12 million tons annually to Italy, may not be in a position to deliver coal to Denmark. As a result of coal and coke shortage, purchases are limited to one week's supply for individuals and two weeks' supply for industries.

Nor is the situation with regard to petroleum products a happy one. The Norwegian tanker fleet, the third largest in the world, is in the possession of the allied powers. Neutral tankers will hardly venture toward Norwegian ports against the British blockade. The conquerors have no oil to spare for civil uses in the Scandinavian nations when their own war needs are limited. The prospect of a fuel famine with its dire consequences rises like a specter on the horizon.

The situation in Norway is particularly critical. Although Norway uses a smaller quantity of liquid fuels than either Sweden or Denmark, she depends upon motor fuels and gas oils to operate her vast fishing and shipping fleets, so vital to the Norwegian food supply.

[1] Coal shipments from the United States to Scandinavian nations in 1940 were as follows: January, 19,611 long tons; February, 83,478 long tons; March, 80,406 long tons.

The fate of stocks of refined oil products in Norway at the time of the German invasion is not known. If these were sequestered by the German forces for military use, then it appears unavoidable that severe suffering and food shortages will occur next winter.

The Swedish position appears to be more fortunate than Norway and Denmark only in one respect. The nation is now virtually in German hands and Germany could enforce whatever demands she might choose to make without firing a shot or landing a company of soldiers. The nation therefore is spared the rigors of an invasion and occupation by armed forces. Sweden can not operate her industries for two weeks without the help of German coal. Germany is therefore in a position to compel the Swedes to safeguard the iron ores vital to German needs, and, if need be, improve the dock facilities at Lulea and increase the capacity of the iron ore railroad. In fact, if the Germans wish to use the port of Narvik by way of Sweden and the Gulf of Bothnia, it is doubtful if the Swedes can do anything but cooperate.

The immediate problem of Scandinavia, during the period of hostilities, is to re-orient their industrial and commercial activities to a condition which has cut them off from the world beyond the Baltic. How formidable is this task becomes evident from an examination of these nations' principal items of import. Raw materials vital to agricultural and manufacturing industries were, in normal times, obtained mainly over Atlantic sea lanes. For Denmark, the fertilizer materials essential for the maintenance of soil fertility overshadowed all other mineral imports. Phosphate from Morocco is probably unavailable, while Chilean nitrate imports are subject to the approval of the British government. Potash is still available from Germany, provided she can provide the transportation facilities.

For Norway and Sweden the problem is even more critical. In addition to the imports of foodstuffs and the contribution of ocean fisheries, these nations imported significant tonnages of two groups of minerals, the fertilizer group and industrial ores. The former are derived from the same sources and present much the same problem as that confronting Denmark in her efforts to maintain soil productivity and a food supply. The industrial ores and minerals furnish the raw materials for the manufacture of specialized and high quality materials with which Norway and Sweden, particularly the latter, supplied the industrial nations of western Europe. Among these are chromite, manganese ore, alumina and bauxite, china clays, refracting materials, gypsum, rough copper, sulfur and salt. A trade treaty for the exchange of goods between Sweden and Russia will scarcely compensate for the loss of Sweden's trade with the West. For various reasons—a lack of the raw materials needed in Swedish factories or inadequate transportation facilities or long overland distances for the transportation of industrial ores—the USSR will be unable to supply the materials of which Sweden is now deprived. Moreover, she remains utterly dependent upon Germany for coal and coke, for it is hardly conceivable that Russian coal, even if it could be spared for export, could be shipped by land and water from the Moscow Basin or the Donetz Basin in sufficient quantities to maintain Swedish industrial activity.

The immediate outlook is one of industrial depression, increasing unemployment and shortages of materials of foodstuffs becoming more acute with time. With regard to the more distant future, it appears that only a decisive victory for the western powers can save the Scandinavian countries from becoming dependencies of the German Reich.

TREND OF RACES IN CANADA

The British races, which represented 51.9 per cent. of the Canadian population in 1931, accounted for only 40.6 per cent. of the births; the French with 28.2 per cent. of the total population contributed 38.9 per cent. The Anglo-Saxon births were thus some 22 per cent. fewer than expectation on the basis of their numerical importance in the population as a whole and the French exceeded expectation by 38 per cent. on the same basis. Save for the Asiatics, who are numerically the smallest in the table, births for the other groups varied much less from expectation than did those of the dominant Canadian stocks, despite their having distinctly unfavorable sex distribution. That, of course, does not apply to the North American Indians.

These figures reveal much as to the prospective racial composition of the population. If the differential fertilities of the principal origins in Canada continue at anything like the present levels, British races before long will constitute a rapidly decreasing minority and other races a rapidly increasing majority of the Canadian population. Disproportionately heavy immigration of Anglo-Saxons from abroad would, of course, retard the decline in the relative importance of that origin, while disproportionately heavy emigration (which takes place at the ages of highest fertility) would hasten it. Non-Anglo-Saxon races are already contributing almost 60 per cent. of the gross additions to the Canadian population, by birth. They are contributing an even larger proportion (70–75 per cent.) of the *net natural increase* because their age distribution, for the time being at least, is peculiarly favorable to low mortality. Change in ethnic structure is, of course, cumulative and the rapidity with which two series of population growth diverge increases with the passage of time in the absence of offsetting influences such as immigration or changes in differential birth and mortality rates. On the present basis of natural increase, it will be only a few decades until the French are numerically the largest race in Canada and a few generations until foreign European races will outnumber the Anglo-Saxons.—*W. L. Hutton, in The Eugenics Review (London).*

BOOKS ON SCIENCE FOR LAYMEN

FACT OR FALLACY[1]

ARE telepathy and clairvoyance actually within the range of powers of some individuals or are they imaginings of superstitious and credulous minds? This book presents the evidence obtained from experiments during the past sixty years for the purpose of obtaining a scientific answer to these alternative questions.

Telepathy—the influencing of one mind by another at a distance without the mediation of any of the senses—is found, upon analysis, to be at the basis of belief in magic, and it enters largely into theology. Belief in telepathy having thus come down in the traditions and folklore of all peoples and having acquired sanctity in their religions, it is naturally very widely accepted, at least in some vague form.

Clairvoyance—foreseeing the future—is implicitly assumed in all beliefs in oracles and prophets, and consequently permeates nearly every theoolgy. Our minds have been so thoroughly conditioned to the acceptance of telepathy and clairvoyance that we ought not to be surprised that a magician will draw a larger audience even in a college than a lecturer on literature, science or philosophy. Primitive mass beliefs often completely blanket the most brilliant achievements of the human mind.

Yet many scientists reject both telepathy and clairvoyance as impossible. They recall that the cruder forms have gradually disappeared as knowledge and critical attitudes have increased. They note that the most confident followers of these theories are usually ignorant, credulous and lacking in intellectual integrity. Moreover, these scientists are unable to conceive of any mechanism or means by which one mind independently of the senses can be in contact with another or can foresee what is beyond the curtain that shuts us off from the future. A few of them, however, make the rejoinder that many times in the history of science apparently absurd beliefs of primitive peoples have contained elements of important truths. Beliefs so widely held, whether or not they are of any value except for the comfort they give those who entertain them, are evidently worthy of examination with scientific thoroughness. This is what has been attempted repeatedly during the past sixty years, and in recent years most energetically and persistently by Dr. Rhine and his associates. These many investigations have been reported in this book. There can be no doubt that many of them and probably all of them have been undertaken with full honesty of purpose, and there can be no doubt that the authors of the present report make every effort to be scientifically objective and impartial. The conclusion reached is that there is evidence for extra-sensory perception (abbreviated to ESP), but evidently this bare statement should not be accepted by the reader without considering the nature of the experimental data and the methods by which it was obtained, for they are by no means so direct and simple as he might readily assume.

The conclusion that ESP is to some extent a reality depends upon statistical discussions which contain many pitfalls, though competent authorities have vouched for the correctness of those which the authors have used. Even so, the conclusions are not so convincing to the ordinary mind as they would be if they had been derived by some simple, direct test. But no simple, direct test has been found that answers the question as to the reality of ESP.

[1] *Extra-Sensory Perception after Sixty Years.* By J. G. Pratt, J. B. Rhine, Burke M. Smith and Charles E. Stuart. xiv + 463 pp. and 361 references to literature. $2.75. 1940. Henry Holt.

It is impossible within reasonable limits of space to describe intelligently the method of testing the reality of ESP, but the spirit of the method can be simply illustrated. Suppose the numbers 1 to 6 are painted on the six faces of a perfect cube. To test whether a person A has the power of *telepathy*, suppose another person B takes the cube into a closed room, shakes it in a box and throws it at random on a horizontal plane. After B notes the number that is on the top face of the cube and thinks of it intently, the "subject" A in another room attempts to state what it is. If he has no power of telepathy, he has one chance in six of guessing the correct number, and on the average of many trials will guess the correct number almost exactly one sixth of the time. This conclusion has been verified by many experiments. On the other hand, if he has perfect power of telepathy, he will call the correct number every time. Such a subject has never been found. But in many cases subjects have called the number (at least the corresponding thing in the real experiments) appreciably more than one sixth of the time. Such persons are concluded to have some power of telepathy. If a subject calls the correct number on the average one third of the time, it is concluded that he has good powers of telepathy, for, as can be determined by calculation, the probability of such a score in a long series is very small. In some experiments subjects have made scores against which the probability on the basis of pure chance is more than a million to one.

To test whether a person has *clairvoyant* ability, the subject might be required to guess what face of the cube will be up in advance of its being thrown. Surely the ability to foretell such an event is any amount simpler than to predict the details of an accident that occurs later in a distant place.

There are many questions concerning these experiments that will promptly arise in any inquisitive mind, most of which have been asked by investigators in this field. For example, are the so-called "psychics," who will use their powers for pay, good subjects? Are superstitious old women who believe they have exceptional powers good subjects? If a person is a subject at one time is he (or she) always a subject? Has he (or she) the power regardless of who the other participant in the experiment may be? What are the effects of stimulating and depressive drugs? Of fatigue or the hypnotic state? Of the distance between the subject and the other person? Of their personal relations? And so on in almost an endless list. Answers to many such questions are given in the book.

What conclusion will a person get from reading the book? He will certainly be convinced that proof or disproof of ESP is a very difficult task and that a vast amount of sincere work has been done in attempting to establish one. If he is not a mathematician, the statistical discussions will probably not be very convincing and he will lay the book aside with his original opinion or prejudice essentially unchanged. But he will agree that it has been very much worth reading.

F. R. MOULTON

STRANGEST OF ALL POSSIBLE WORLDS[1]

THE wonderland which Dr. Gamow gives us in this delightful, thought-provoking book is far more wonderful than the setting for the remarkable adventures of Alice; for the latter world is one of pure imagination, while the former—apart from a really insignificant difference—is the one we actually live in. Curiously enough, the creator of Alice (like the Creator!) was a mathematician, but it remained for the relativity theorists to construct for us the wonderland

[1] *Mr Tompkins in Wonderland.* By George Gamow. x + 91 pp. $2.00. 1939. Cambridge University Press.

to end all wonderlands. It is to the credit of the author, whose technical contributions in the field are of first rank, that he is able to treat some of the astonishing consequences of the relativity formulation of the world in a not-too-serious vein.

The book concerns the amusing nightmares of Mr Tompkins, an ordinary mortal who after attending three popular lectures on relativity and quantum theory dreams that he inhabits several worlds where "phenomena usually inaccessible to our ordinary senses are so strongly exaggerated that they could be easily observed as the events of ordinary life." These worlds are governed by the same physical laws as our own, but with different numerical values for the physical constants, so that what appear to us to be slight (and usually negligible) "corrections" to the classical laws of physics are for Mr Tompkins very real and startling matters of daily experience.

Many of us, especially those not accustomed to the highly abstract way of thinking demanded by a formal study of the newer theoretical physics, will welcome Dr. Gamow's little book. Relativity and the Quantum Theory are subjects uncommonly difficult to interpret to the layman. Often such popularizations recourse to misleading analogies which confuse rather than clarify. The author's ingenious device of delineating the true story by changing the scale of the picture is what makes his book instructive as well as fascinating.

In the Appendix, the three lectures which induced Mr Tompkins's unusual visions are set down. They constitute as superb a piece of interpretive writing as anything that has appeared in this difficult territory of science.

The uniformly excellent and appropriate drawings illustrating the text are by John Hookham. Some readers may be puzzled by his avoidance of the conventional five-pointed star in several of the drawings.

Altogether, "Mr Tompkins in Wonderland" is entertaining, stimulating and instructive. The literature of popular science is richer for the existence of such a book.

IRA M. FREEMAN

BIRDS OF EASTERN NORTH AMERICA[1]

IN the years 1925 to 1929, the Commonwealth of Massachusetts issued a three-volume work on the birds of that state and of the rest of New England as well, from the pen of its late state ornithologist, Edward Howe Forbush. Both in text and in illustrations (by Fuertes and Brooks) it set a very high standard for regional works of its kind, and the demand for it soon exhausted the edition. Now, a decade after the publication of the third volume, it has been deemed wise to greatly condense the text as far as each species is concerned, but to add the hundred-odd birds found in North America east of the ninety-fifth meridian, but not recorded from New England, so as to make a single volume covering the eastern half of the continent. All the colored plates of the original work have been included and, in addition, four new ones by Roger Tory Peterson, depicting 27 of the notable southern species. Dr. May, who assisted Forbush in the earlier work, has prepared the abridged version. The result is a book of decided usefulness, illustrated in a manner that would otherwsie have been impossible in a work in its price class. Unfortunately, the plates have not been as carefully printed as in the original edition (the blue jay, pl. 58, for instance, is much too purplish; the horned larks, pl. 57, too reddish; the spoonbill, pl. 96, is not the right shade of pink, etc.).

The textual matter appears to have been condensed without any attempt to

[1] *Natural History of the Birds of Eastern and Central North America.* By Edward Howe Forbush. Revised and abridged by John Richard May. Large 8vo. xxvi + 554 pp. 97 col. pls. $4.95. 1939. Houghton Mifflin Company.

bring it up to date. The items in the original version of the work that have been sacrificed for brevity have been the descriptions of plumages (which are largely taken care of by the plates), molts, measurements and local distribution and frequency of occurrence in New England. Furthermore, the paragraphs dealing with field identification marks, geographic range, nesting habits and season, have been reduced to concise, terse, almost telegraphic statements. The arrangement of the higher groups and their included species and also the scientific nomenclature used have been changed to conform to that of the fourth (last) edition of the American Ornithologists' Union "Check-List of North American Birds," which was published some time after the original version of Forbush's work.

A brief account of the background of the work and of the life of its original author forms an introductory chapter, while in the back of the book is given a nominal list of the birds of only accidental or casual status in eastern North America. There are two indices, one limited to scientific names and the other to the common names used in the book. There should be a wide usefulness for this volume.

HERBERT FRIEDMANN

AN OUNCE OF PREVENTION[1]

IT is an ancient adage that prevention is sixteen times more effective than cure. From the medical viewpoint such evaluation of the relative merits of prevention and cure is far too conservative. The importance of extremely early discovery of disease is well appreciated by Dr. Malford W. Thewlis in his new book.

The volume is hardly suited to nonmedical readers, but it should stimulate interest. The author has a thesis and apparently he made a superficial search of the literature for views which support it and largely ignored the rest. This thesis is that "Scientific individual prophylaxis is only possible when it is known what specific organic weakness is present." This is a fundamental truth, but unfortunately the suggestions as to how to ascertain such knowledge are weak. There is a lack of consideration of many clinical function test studies intended to reveal slight or moderate diminution of function reserve capacities. Symptoms of functional failure do not appear until functional capacity falls below functional requirements. Thus it happens that the huge reserves of the body may be silently depleted without symptoms which can but be revealed by test studies.

There can be no question of the value of any and all emphasis placed upon this viewpoint. Too long have practitioners of medicine been content to treat the sick and leave preventive medicine to "public health" methods of wholesale prophylaxis. The virtual conquest of typhoid fever, the control of malaria, the elimination of devastating epidemics of juvenile contagious diseases and many other impressive victories of preventive medicine are largely dependent upon impersonal and engineering measures. It is time preventive medicine became *individualized* and that the patient himself assume more of the responsibility for maintaining his own good health. And herein lies the most difficult problem of application of prophylaxis, which Dr. Thewlis hardly mentions. Personal preventive medicine involves effort and compliance with restrictions on the part of the patient. People rarely make personal effort to maintain health, though they will go great lengths in attempting to restore that which their own neglect helped lose. The emphasis of the importance of periodic health inventories is timely, but the book fails to point out sufficiently the pitfalls of such work in the infinite variability of individuals in their heredity, constitution, habits, personality and in their previous injury from the innumerable vicissitudes of existence.

EDWARD J. STIEGLITZ

[1] *Preclinical Medicine.* By Malford W. Thewlis, M.D. iii + 223 pp. $3.00. 1939. Williams and Wilkins Company.

NICHOLAS COPERNICUS

THE PROGRESS OF SCIENCE

THE QUADRICENTENNIAL OF THE "FIRST ACCOUNT" OF THE COPERNICAN THEORY[1]

COPERNICUS (1473–1543) was reluctant to publish his revolutionary theory that the earth moves, that it is a mere planet and all the planets revolve about the central sun. His "Commentariolus" in manuscript, describing the main points of his system, was circulated among sympathetic friends perhaps as early as 1512–15. His other minor work, "The Letter Against Werner," 1524, though polemic, avoided the heliocentric issue. His "absurd" ideas were ridiculed on the stage at Elbing in 1531. Papal secretary, Widmanstad, reported the new theories to Pope Clement VII in 1533, and Cardinal Schönberg in 1536 urged Copernicus to announce his system to the world.

When Rheticus, an unexpected visitor at Frauenburg in 1539, was welcomed by the aged astronomer, an intimate friendship began in spite of differences in age, country and creed. Rheticus, a German and a Lutheran, at 22 years of age in 1536 was a professor of mathematics at Wittenberg, storm-center of rising Protestantism. Copernicus, a Pole, approaching three score years and ten, was a Catholic canon, loyal to the church, bold in mind but anxious to avoid antagonism. He entrusted his manuscript of "De Revolutionibus" to his enthusiastic disciple and assisted him in mastering the contents. After "scarcely ten weeks" of study, Rheticus prepared and sent to his former teacher, John Schöner, of Nuremberg, his famous "Narratio Prima," which was published in 1540, just 400 years ago, *the first printed account of the Copernican theory.*

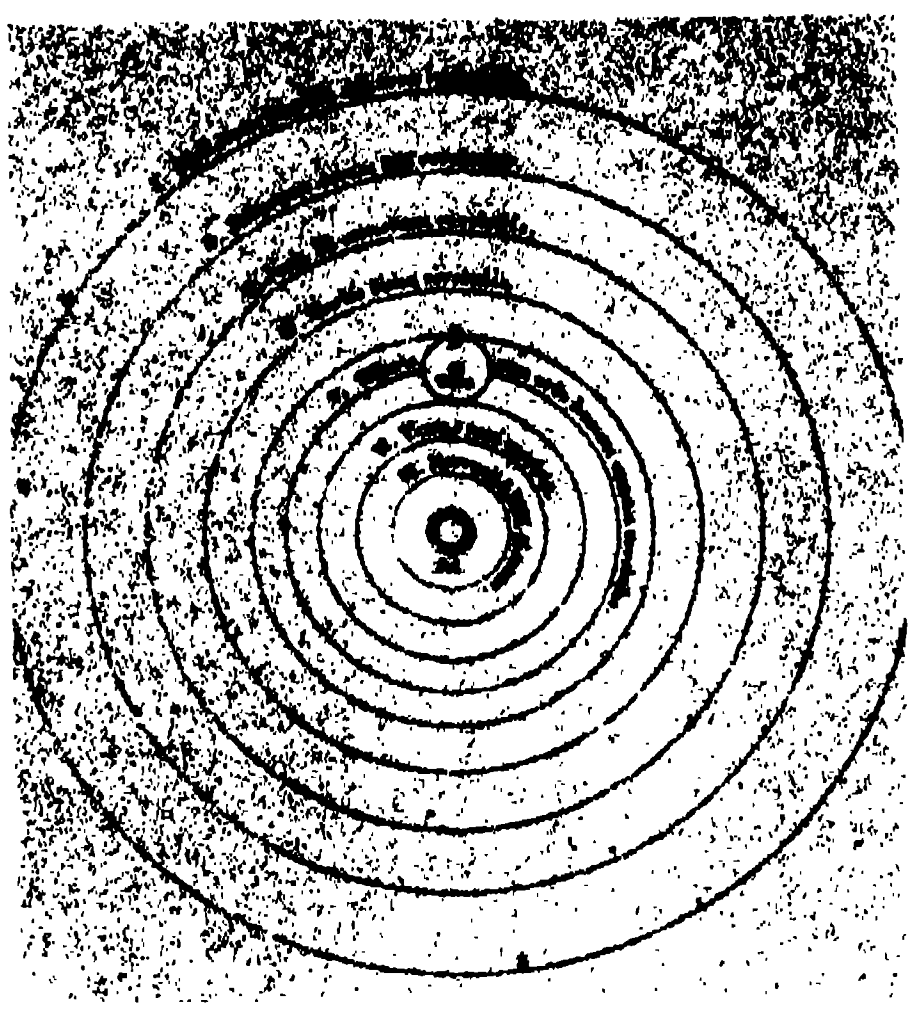
Although Rheticus intended to announce the heliocentric theory, first mention of it occurs about one third from the beginning. Before taking the final step, he evidently desired to impress his readers with the learning and achievements of his "Dominus Doctor," whose name does not appear. Copernicus was compared favorably with Ptolemy and Regiomontanus, the most distinguished astronomers of the second and the fifteenth centuries, respectively.

Rheticus passes the first and second books of the manuscript with brief comment. The first contains a general description of the heliocentric system and the second discusses apparent diurnal motion, which Rheticus says "does not differ from the common and received opinion."[2] The third book, given chief consideration, treats of the motion of the sun (?), the motions of the fixed stars (?) and the mutations of the equinoxes and solstices. Copernicus sets out not merely to "save the phenomena" but also to save the principle of uniform circular motions about their centers, which Ptolemy violated by the use of equants.[3] A large amount of data by the Greeks and later observers, including some by Copernicus, was used and the superiority of the results of the master was stressed. Precession of the equinoxes was considered variable, due to large observational errors, but its

[1] G. Joachimus Rheticus, *De Libris Revolutionum Narratio Prima*, Danzig, 1540. Georg Joachim von Lauchen, 1514–76, called Rheticus from Rhetica, the Latin name of the province of his birth. Quotations are from the translation by Edward Rosen, "Three Copernican Treatises," New York, 1939.

[2] An unequivocal statement of the truth, as Rheticus realized, would here divulge the fundamental difference between Copernicus and Ptolemy regarding the real diurnal rotation of the earth.

[3] The equant is an imaginary eccentric point from which the apparent motion seems to be uniform.



THE COPERNICAN SYSTEM

mean value was given quite accurately, about 50″ in an Egyptian year. Due to variable precession the length of the tropical year was considered variable and Rheticus himself attempted to harmonize discrepant results obtained at different periods. This was done to his complete satisfaction, "not without the greatest pleasure." The master advocated using the constant sidereal year and found its value to be about $365^d\ 6^h\ 9^m\ 36^s$.

The obliquity of the ecliptic was also considered variable. Available data showed a continual decrease from about 23° 51′ to 23° 28′, but Copernicus assumed it would be periodic and deduced 3434 years. Ptolemy was criticized for holding that the apogee of the sun was fixed and Rheticus advocated its twofold motion, "one mean and the other unequal." He also accepted the independent motions of the apsides of the other planets.

Here Rheticus abandons Copernicus and becomes astrological. "This small circle is in very truth the Wheel of Fortune, by whose turning the kingdoms of the world have their beginnings and vicissitudes." Also the end of the world will come when the eccentric reaches the value it had at the creation. The data call him back to the task of saving the phenomena, "marshalled on the battlefield of astronomy by the observations of 2,000 years, as by famous generals." But there is another delay in the announcement. The new lunar theory treated in book four is introduced, the equant is abolished and all the observations are satisfied. Similarly in the case of the planets with their motions, direct and retrograde.

Then comes the climax, the great announcement: "These phenomena, besides being ascribed to the planets, can be ex-

NICHOLAS COPERNICUS
FROM A PAINTING BY BRAUSEWETTER.

plained, as my teacher shows, by a regular motion of the spherical earth; that is, by having the sun occupy the center of the universe, while the earth revolves instead of the sun on the eccentric, which it has pleased him to name the great circle. Indeed, there is something divine in the circumstance that a sure understanding of celestial phenomena must depend on the regular and uniform motions of the terrestrial globe alone." But the courage of the author's convictions apparently falters as he adds later: "Which of these assumptions is preferable, I leave to be determined by geometers and philosophers (who are mathematically equipped)."[4]

The arrangement of the spheres is described with the sun at the center, "governor of nature, king of the entire universe, conspicuous by its divine splendor." (See accompanying diagram.) The diurnal rotation of the earth accounts for day and night and the apparent diurnal motion of the celestial sphere. The annual revolution of the earth explains the apparent annual motion of the sun and with the heliocentric orbits of the planets accounts for their apparent convolutions. The seasons are explained by a third motion, a conical turning of the earth's axis, considered necessary to keep its direction constant during the year, because the geometrical method employed made use of a moving radius vector rigidly attached to sun and earth. But its period was slightly less than a sidereal year and the small difference was correctly attributed to the mean precession, which constituted a fourth motion also variable. Here we have the first correct explanation of that phenomenon, a high tribute to the genius of Copernicus.

The great object was attained. All the celestial motions were explained by a simplified, harmonious system based on real motions of the earth around the sun, "which may be said to be the source of motion and of light." Some vestiges of the geocentric system remained, also the metaphysical assumptions and the limitations of the geometrical method. But little advance over the ideas set forth in this preliminary announcement by Rheticus was made by Copernicus in his "De Revolutionibus." On this foundation, moreover, Tycho Brahe, Galileo, Kepler and Newton added the superstructure, the analytical solution of the problem of motion of the heavenly bodies.

W. Carl Rufus

[4] The assumptions, though figuratively expressed, refer to the sun at rest or in motion.

THE OSLER MEMORIAL BUILDING AT "OLD BLOCKLEY"

Behind the group of beautiful new buildings that compose the present great Philadelphia General Hospital—Old Blockley—there stands, a kind of relic of the past, a small, crude, two-storied, square brick building, very old and very shabby, known to every one of the present day as the "paint shop," but to those of older generations as the "morgue," the "mortuary," the "dead house" or the "green house," according to their particular vintages. For years it has been a place in which paints were stored, and bedsteads and other furniture painted. But it has peculiar interest attaching to it.

In the summer of 1884 Dr. William Osler, the new professor of clinical medicine in the medical department of the University of Pennsylvania, arrived in Philadelphia, to prepare for his winter's work. He at once saw that the number of beds assigned to him in the University Hospital was inadequate for the carrying out of the plans of bedside instruction that he contemplated, and turned his eyes toward the Old Blockley Hospital to whose medical board he was soon

THE MEMORIAL BUILDING AT THE PHILADELPHIA GENERAL HOSPITAL

elected and where he remained one of the most active and useful members until he left Philadelphia to go to Johns Hopkins in 1889.

Fifty years ago few autopsies were made in any Philadelphia hospital, and there was no demand for the complicated examinations that now overwhelm the great modern hospital laboratories. The little old "dead house" was, therefore, adequate to the purpose for which it was intended. The post-mortem room was small, with a simple autopsy table in the center, lighted at night or on dull afternoons by a double gas jet overhead. In front of the largest window, there was a high desk, upon which lay an enormous tome in which the autopsy records were written, as and if time permitted, by a resident physician appointed to act as clerk. As autopsies came at unexpected times, and he had many other duties, it often happened that he could not be found, when no notes were kept.

The pathologist to the hospital at that time was Dr. Henry Formad, who was also the demonstrator of pathology in the medical department of the University of Pennsylvania and the coroner's physician. He was a very busy man, as may be imagined, and therefore inclined to hurry through such autopsies as he was called upon to make, and to dictate very short notes. He was, also, inclined to escape the post-mortem operations altogether, when possible, by deputizing their performance to any member of the medical staff, or even any resident physician who was anxious or willing to conduct them.

This state of affairs in the autopsy room was Osler's opportunity, and he proceeded to make the most of it, dividing his time in the institution between the wards, where he studied the patients while alive, and the "dead house," where he examined their bodies after death. In the former he was just one of the medical chiefs, but in the latter he was the master pathologist, the ardent morbid anatomist and the willing and able teacher. He, therefore, gathered all the

younger men about him, and gave them never-to-be-forgotten lessons. There are many who remember him chiefly as a pathologist, which is unfair, for he was a great clinician.

When he was at work upon an autopsy, time seemed to lose all other values for him, and he sometimes worked over one body for hours. Nor was that all, for when he was at last finished, he would sometimes mount the high stool and write voluminous notes in the record book with his own hand, not trusting to the clerk, who might be inclined to skimp, or slur over, or omit altogether what was dictated, believing that the omissions would never be discovered.

The idea of transforming this old building into a memorial to him who long years ago had frequented it, who had there done much of the work for which he was famous and whose memory hallowed it was the inspiration of Dr. David Riesman, the former professor of clinical medicine in the Medical Department of the University of Pennsylvania and the chairman of the Medical Board of the Philadelphia General Hospital.

The idea of dedicating such a dilapidated edifice as a memorial may have shocked some persons and made others smile. It may even have been because it would cost the city nothing that caused the City Council to act favorably upon the recommendation, which they immediately did, but without providing any funds for reconstruction or rehabilitation. Moreover, the hospital had no other place suitable for the paint shop. So nothing was changed, and no progress made for several years. In the meantime, Dr. Riesman did not despair, but kept on working to bring his vision to fruition. He was, therefore, able to

ARTIST'S CONCEPTION OF CONSULTATION WITH OSLER
A PAINTING BY MR. DEAN CORNWELL.

announce at a time when many had forgotten all about the matter, that the members of the drug firm of John Wyeth and Brother had agreed to take charge of the matter, and that they would not only rehabilitate the edifice, but that they would also employ Mr. Dean Cornwell, R.A., to paint a picture of "Osler at Old Blockley" with which to adorn it when finished.

This proposal found immediate favor, and the hospital a new paint shop. Work was therefore begun. Such attention as it now received had been unknown to the little building for at least three quarters of a century. It was reroofed, repointed, repainted and replastered. Old partitions were replaced, so that it was again the structure as Osler knew it. It was, indeed, so furbished up as to be almost unrecognizable to those most familiar with it, just as a man whom one is accustomed to see in dingy overalls, with dirty face and hands, may scarcely be recognized when dressed for church on a Sunday morning. It was the same building, however—not changed, but glorified.

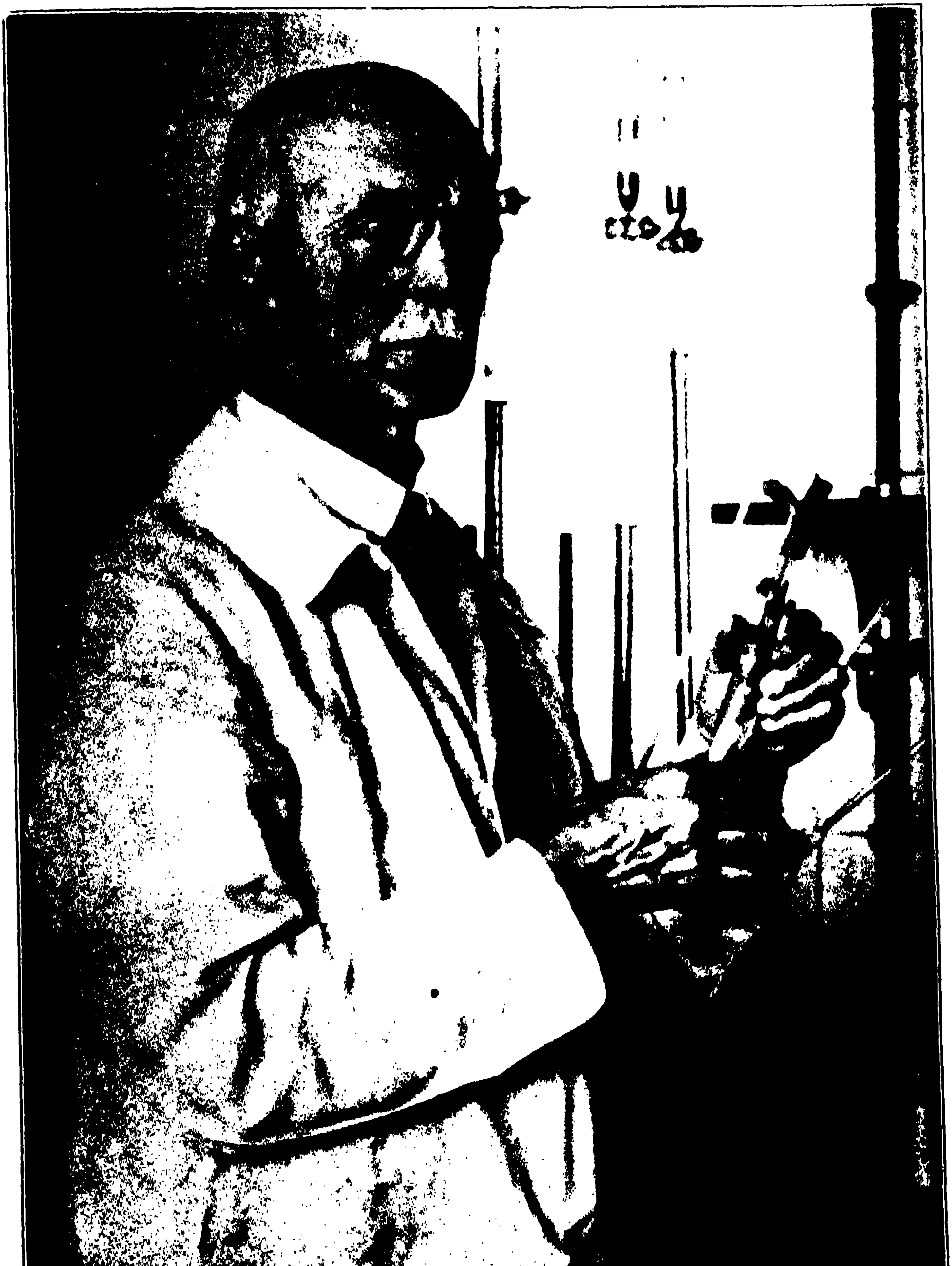
The dedication of the memorial was held on the afternoon of June 8, 1940, the exercises having been arranged by a committee consisting of Dr. David Riesman, chairman, Dr. William E. Hughes, Dr. William G. Turnbull, Dr. William N. Bradley, Dr. Jefferson H. Clark, Dr. Marion Rea and Dr. Robert J. Hunter. Invitations were sent far and wide to the profession and laity and brought more than a thousand guests to crowd the Auditorium of the hospital, overflow into the hospital and spread through the grounds. There was, however, one sad note, for Dr. Riesman, by whom the whole had been planned and who was to have p[illegible] at the ceremony, had died but a short time before. Very appropriately, the first address, given by Dr. William Egbert Robinson, was a eulogy to him.

Dr. William E. Hughes made some introductory remarks, Dr. Joseph McFarland spoke of "Osler as I Knew Him," and Dr. W. B. McCallum, of the Johns Hopkins University, of "Osler at Blockley."

At the close of the program everybody walked out into the hospital grounds to visit the memorial building. Old Blockley had not seen such a brilliant company of well-dressed ladies and gentlemen for many a long year, if ever before. The little building was constantly filled with those anxious to recall earlier days, or to satisfy their curiosity, while long lines awaited their turn. Much interest centered about Cornwell's painting, which was a surprise and something of a disappointment.

As Osler left Blockley more than fifty years ago, the artist could only represent things as he imagined them with the aid of such suggestions as a few of the older men could give him. The result of this artist's license is certainly interesting, and possibly meritorious, but it is not historic, and there are still enough oldsters of the Oslerian period about to point that out. Perhaps no one can say that no such scene ever took place, but no one can remember ever having seen Osler sitting out of doors, surrounded by a large group of resident physicians, discussing an old female patient lying on a stretcher, while a well-dressed lady from outside listens to what he has to say. It is, perhaps, unfortunate that he has been so represented, for years hence, when all who lived at that time have passed away, the picture may be brought forward in evidence that such outdoor clinics were the custom between 1884 and 1889.

JOSEPH MCFARLAND



SIR ARTHUR HARDEN

EMERITUS PROFESSOR OF BIOCHEMISTRY AT LONDON UNIVERSITY, WHO DIED ON JUNE 17. HE SHARED THE NOBEL PRIZE IN CHEMISTRY FOR 1929 WITH PROFESSOR HANS VON EULER, AND WAS KNIGHTED IN 1936 BY KING EDWARD VIII.

THE SMITHSONIAN-FIRESTONE EXPEDITION TO LIBERIA[1]

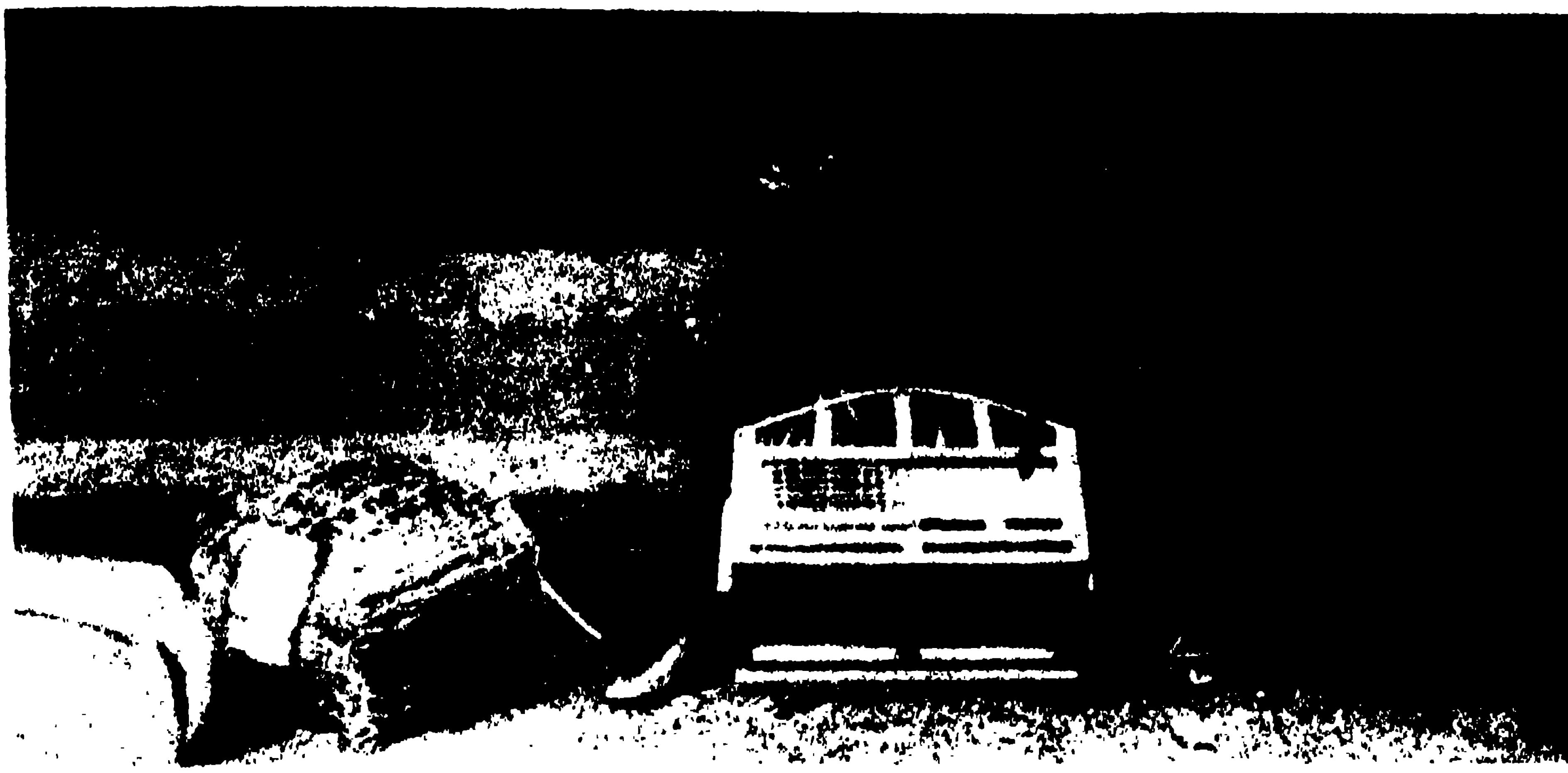
Two of us, accompanied by Ralph Norris and Roy Jennier of the National Zoological Park, sailed in February for Monrovia, via Dakar, Conakry and Freetown.

At Monrovia we were greeted by George Seybold, maanger of the rubber plantation, and taken to his home at Harbel, fifty miles inland. The plantation remained our headquarters during our stay of four and a half months in the country. In addition to comfortable living quarters we were supplied with a "rice shed" in which to keep animals. This was so enormous a warehouse that we despaired of ever securing enough animals to make a showing in it.

We spent a large portion of our time on five different trips into the interior, living in native villages and getting the bush natives to collect live animals. Our first journey was to Belleyella, a six-day walk inland, and our first experience with hammock travel. The caravan travels throughout the day, native boys not caring to rest at noon but preferring to reach their destination, where they eat their one meal of the day—usually rice and palm oil. During the hotter part of the day one rides in a hammock, which is fastened to a frame and carried on the heads of four boys. On approaching or passing through a village they sometimes break into a dance, accompanied by chants and the beating of drums by the extra carriers—quite a spectacle, but one which left us feeling at night as though we had ridden horseback a long day's journey over a hard road.

[1] The Firestone Tire and Rubber Company financed this expedition, which was for the purpose of collecting live animals for the National Zoological Park in Washington, D. C.

A DUG-OUT CANOE SERVES AS FERRY ACROSS THE ST. PAUL RIVER



NATIVE-MADE ANIMAL BASKETS

THESE SPECIALLY MADE BASKETS, WHICH WERE BALANCED ON THE PORTERS' HEADS, WERE CARRIED BACK TO BASE CAMP.

Because of food requirements for our caravan boys it was necessary always to camp in native villages, where comfortable mud huts were furnished us. We were surprised at the absence of annoying insects and other pests. There are mosquitoes that cause malaria but they bite very quietly; we never saw a bedbug or a flea, and very few cockroaches or other fauna which in most places in the tropics tend to do away with any life in a native village.

Our first acquisition was a young chimpanzee whose mother had been shot two days before near our trail. A potto discovered asleep on a branch overhanging the trail was shaken down and popped into a bag. A tiny squirrel-like dormouse brought to us tied to a short string adapted itself immediately to being a pocket pet. The only pet observed in native villages was an occasional mongoose-like animal. We bought a few of these, as well as several baby civet cats.

A number of young hornbills were secured by sending natives up to rob nests in hollow trees. Rhinoceros and Gaboon vipers were brought in to us commonly, as well as hinge-back tortoises and a broad-nosed crocodile. This last lives in small streams in the forest and is very seldom seen.

All our bush trips were similar. On one we camped for a week at the base of the sacred mountain in the Gibi country but were unable to secure permission to collect at any altitude there, as the natives consider the forest holy and have never allowed any outsider, white or black, to enter. We did collect on a similar mountain eight miles to the north from our camp, and obtained batrachians, fishes and insects at an altitude of about 400 feet above the base of the mountain (which was perhaps 2,000 feet high).

A side trip was made to the American Episcopal Mission at Bromley on the St. Paul River, where an employe of the Mission who was also a member of the secret Snake Society secured some specimens for us, and we fished a nearby stream, accompanied by Bishop Kroll and the staff of the school. An army of driver ants occupied the only accessible

PARAMOUNT CHIEF BOIMA QUAE
OF BENDAJA, CAPE MOUNT DISTRICT, LEADER OF THE GOLA TRIBE.

part of the stream's bank. After observing them for a while in the hope of finding Dorylophiles (beetle guests), we dispersed them by throwing buckets of water on the column, which after half-an-hour's flooding turned in another direction.

From Cape Mount near the Sierra Leone frontier we went into the Gola country at Bendaja, a two-days journey.

A BABY PIGMY HIPPOPOTAMUS
AT THE BASE CAMP AT HARBEL.

Traveling by launch, dug-out canoe, on foot and, when the path permitted, in rickshas devised by the missionaries there, and made of cane chairs mounted on bicycle tires—a convenient method of travel for an entomologist, who with a little practice can sit in the chair and net tiger beetles that fly by, as the two ricksha boys, one in front and one be-

A KPELLE GIRL
THE HEAD-DRESS AND CICATRICES ON THE ABDOMEN SHOW THAT SHE HAS COMPLETED HER TWO YEARS' SECLUSION IN THE BUSH SCHOOL.

hind, trot along the road. Our camera boy, Pepe, would run alongside the ricksha and now and then stoop and grab a beetle, the forty-pound load on his head being of no inconvenience at all.

At Bendaja one of the local hunters was especially skilful at netting antelope, and we returned with two water chevrotains, which had to be carried in palm-wood baskets on the heads of porters on the return walk through the

A BABY CHIMPANZEE
SWINGING ON A YOUNG RUBBER TREE OUTSIDE THE BASE CAMP.

forest and along the beach to Cape Mount.

Our last inland walk was to a cocoa plantation that had been established by Polish immigrants, who had abandoned it to return to their own country at the outbreak of war.

While we were making these various bush trips, Mr. Norris and Mr. Jennier managed the rice shed, and natives brought in whatever they could find in the way of live animals. The collection grew slowly but steadily. One lot was sent home in May in charge of Mr. Jennier, and spent the summer at the Firestone exposition at the World's Fair in New York.

Toward the end of our time the propaganda we had made in the more distant villages produced results and four pigmy hippopotami were brought in. One of them had had its skull cracked and was dead before we saw it. Two of the others lived to reach the States and are thriving at the present time.

The collection which we brought home in August on the *S.S. West Irmo* of the Barber Steamship Line, after a 21-days run from Monrovia to Norfolk, included six duiker antelope of three species, four water chevrotains, a ratel and a water civet, crested eagles and other species new to the national collection. In addition some thousands of alcoholic and dried specimens were collected for the National Museum, where they are being assorted for study.

William M. and Lucile Q. Mann

THE ECLIPSE EXPEDITION AT PATOS, BRAZIL

Because broken clouds partly veiled the sun at Patos, Brazil, during the period of totality of the solar eclipse of October 1, only a partial record of the eclipse could be made through the instruments set up there by the expedition

of the National Geographic Society and the National Bureau of Standards. A complete report of the work has not yet reached Washington, but brief cables indicate that despite the clouds photographs were obtained of the inner corona and of the flash spectrum—the spectrum of the outer portion of the sun's atmosphere (the chromosphere) which first flashes momentarily by its own light as the light from the body of the sun is eclipsed, and which flashes a second time as the bright atmosphere is uncovered on the other side by the moon's disk, at the end of totality.

The observers report that they also got good records of the four times of contact: the instant when the edge of the advancing moon first appeared to meet the edge of the sun, the instant when the sun became covered by the moon, the instant when the light from the sun reappeared and the instant when the moon moved out of apparent contact with the edge of the sun. A constant check on these contact times is important to astronomers for the calculation of future eclipses.

The expedition's program of tests with radio signals to determine the be-

National Geographic Society

THE INSTRUMENT SET UP FOR OBSERVING THE TOTAL ECLIPSE AT PATOS

IN THE IMMEDIATE FOREGROUND ARE THE TWO LARGE SPECTROGRAPHS WITH THEIR TUBES DIRECTED TO THE POINT IN THE SKY TO BE OCCUPIED BY THE SUN AT ECLIPSE TIME. A REFLECTION GRATING WAS PLACED AT THE BASE OF EACH TUBE SO AS TO PROJECT ONE HALF OF THE SPECTRUM WITH A SPREAD OF 40 INCHES ON PHOTOGRAPHIC FILM AT THE UPPER END (THE FRONT) OF THE RECTANGULAR BOX. THE THIRD TUBE TO THE LEFT IS THE BARREL OF A TELESCOPIC CAMERA. TWO SOMEWHAT SMALLER CORONA CAMERAS FARTHER TO THE LEFT ARE HIDDEN BY THE LARGER INSTRUMENTS. THE EQUIPMENT FOR INVESTIGATING THE BEHAVIOR OF RADIO SIGNALS DURING THE ECLIPSE IS NOT SHOWN IN THE PHOTOGRAPH. THE SMALL TENT SHELTERS THE CHRONOGRAPH AND THE PROGRAM CLOCK. PILED IN THE BACKGROUND ARE SACKS OF UNGINNED BRAZILIAN COTTON.

havior, during eclipses, of ionized layers in the upper atmosphere (the so-called "radio-reflecting layers") was carried out successfully. Fortunately such tests are entirely independent of cloud conditions; the floating masses of water globules do not impede the passage of the radio signals. The impulses were sent vertically upward from a sending station housed in an automobile trailer, and the reflected signals were recorded on receiving instruments in the same enclosure.

M. K.

DR. CHEVALIER JACKSON AND THE BRONCHOSCOPE

DR. CHEVALIER JACKSON
AUTOGRAPHING DRAWINGS FOR HIS PUPILS IN BRONCHO-ESOPHAGOLOGY AT TEMPLE HOSPITAL.

At the age of seventy-four, Dr. Chevalier Jackson recently received the Distinguished Service Medal of the American Medical Association. Although this is just one of numerous awards presented to Dr. Jackson for his remarkable work in bronchoscopy, it demonstrates the esteem by which he is held by his fellow delegates to the annual medical convention in New York.

Though always frail in health and suffering from several attacks of tuberculosis during his career, he has given all his strength and enthusiasm to the practice of bronchoscopy, to the establishment of clinics throughout the world and to the training of assistants to carry on this vital work.

With the bronchoscope, the unusual instrument which he perfected, he has performed amazing feats of skill in saving the lives of many people, especially children, who had swallowed such indigestible objects as nails, tacks and fruit stones. In approximately 98 per cent. of these cases where foreign bodies were removed, the patients not only recovered, but they were completely cured.

MEDICAL ASSOCIATION MEDAL
RECENTLY AWARDED DR. JACKSON.

Gladys Muller

MANIKIN AND THE BRONCHOSCOPE

THE ARTIFICIAL PATIENT UNDERGOES "BRONCHOSCOPIC TREATMENT" FOR THE REMOVAL OF A NAIL.

Quite naturally, then, it has been through these spectacular cases that the bronchoscope has received world-wide recognition, but it is interesting to note that its greatest value lies in the prevention and diagnosis of disease.

The bronchoscope is a thin-walled brass tube about 16 inches long, although smaller ones are used for children. Through this the forceps are passed. These are operated like a pair of scissors. More than a hundred different instruments have been designed for use with the bronchoscope. Among these are a device which closes safety pins before they are pulled up through the tube, a fine sharp knife which cuts off small abnormal growths, and narrow prongs which grasp the head of a nail or tack. None of these ingenious instruments have ever been patented because they were devised solely for the purpose of benefiting mankind.

Light for the operation is furnished by a tiny electric light bulb. Dry cells furnish the necessary current. Placed as it is, at the end of the bronchoscope, the tiny bulb enables the doctor to see the interior of the lungs and bronchi.

In recent years the bronchoscope has been used to tremendous advantage in the early recognition of cancer of the lungs, bronchial tuberculosis and other serious diseases.

There are many people who have heard of the wonders of the bronchoscope and go to one of the clinics hoping to watch a doctor at work, but unfortunately outsiders are not admitted because the strictest sanitary regulations are employed as in other serious operations. But those who are interested in watching how the bronchoscope is operated can see the realistic exhibit at the Franklin Institute in Philadelphia, designed by Dr. Jackson and his only son, Dr. Chevalier Lawrence Jackson.

It consists of a manikin lying flat on its back with the bronchoscope extending from the mouth in the exact position as used in the clinics. One can look through a hole in the glass case which surrounds the exhibit, down through the bronchoscope to the location where a nail is lodged. Pushing a button starts the operation of the exhibit. Air can be felt coming out of the tube which corresponds to a person's "breath," and a faint red glow can be seen which is caused by the tiny light shining on the mucous membrane of the bronchial tube.

Over the manikin is one of the green sheets always used by Dr. Jackson in his clinic. This color, which does not reflect any glare, is preferable over the customary white sheets. The operations are performed in a darkened room so the eye can see more clearly through the small tube in the bronchoscope.

The exhibit is a living memorial to the two doctors who designed it; the one who began as a pioneer in a new and unknown field and became one of the great benefactors in the medical profession, and the other who continues to uphold the high standards set by his father.

EMILY DUANE WALLACE

THE SCIENTIFIC MONTHLY

DECEMBER, 1940

BEARING OF FORESTS ON THE THEORY OF CONTINENTAL DRIFT

By Dr. RALPH W. CHANEY

PROFESSOR OF PALEONTOLOGY, UNIVERSITY OF CALIFORNIA;
RESEARCH ASSOCIATE, CARNEGIE INSTITUTION OF WASHINGTON

FORESTS or continents—which of these have moved over the surface of the earth during the past? This question arises when we consider the fossil forests of the north, where long winters with sub-zero temperatures make it impossible for trees to live to-day. It again comes to mind when we uncover in the rocks of the western United States petrified logs and leaf impressions of trees which now exist only in the tropics. Such records of past life establish the fact of great changes during earth history. But whether these changes have involved migrations of forests southward or movements of whole continents northward is a question on which paleobotanists and geophysicists are not always in agreement.

On first thought it seems more probable that the forests have moved rather than the continents. The span of a human life is too short to witness major changes, but we instinctively feel, as implied by such expressions as "solid ground" and "everlasting hills," that the continents on which we live are the epitome of permanence. Many of us have witnessed changes in forest distribution, largely, it is admitted, through man's clearing of woodlands for other uses. Such superficial observations and reactions can scarcely be weighed seriously in a question involving world-wide changes during scores of millions of years. It is necessary to turn to the fossil record for the solution of a problem which had its beginning long ages before man came to live upon the earth.

The hypothesis of continental drift, as presented by Wegener, assumes the original massing of the existing land masses into an aggregate termed Pangaea. Subsequently the American continents are thought to have broken off and drifted to their present position. As Wegener states in his book, "The Origin of Continents and Ocean Basins," the starting point of this idea of continental union and dispersal was the close correspondence of the coasts of Africa and South America. This suggested that they had once been joined and that they subsequently drifted to opposite sides of the Atlantic Ocean. Evidence was also presented for the fusion of North America with Europe. Wegener concluded that as recently as the geologic period preceding our own, there was only a narrow inland sea separating these continents, and that the Atlantic Ocean as we now know it did not come into existence until the period in which we live. Although his discussion of north-south movements involves some contradictions, Wegener definitely indicates his belief that the position of the continents with relation to the north pole has also changed widely in later

geologic time. Writing more recently, duToit makes the following statements in his book, "Our Wandering Continents": "From the Cretaceous onwards we can accept a series of polar 'shifts,' . . . A general movement at first north, then north-east, thereafter north again and finally east, modified to some extent by the continued *divergence of the two continents*"; and "Indeed, from the mid-Palaeozoic onwards the lands must have crept *northwards* for thousands of kilometres to account for their deduced climatic vicissitudes. *Such, indeed, constitutes the most telling demonstration of the reality of Continental Drift.*"

The paleobotanist approaches the question of continental drift versus forest migration with an attitude which has been current among students of the earth sciences since Hutton and Lyell, over a century ago, put forth the doctrine that the present is the key to the past. Viewing the vegetation of to-day from the pole southward, we note gradual changes from boreal to temperate and from temperate to tropical forests. Dwarfed spruce, willow and birch on the Alaska tundra give way to maple, elm or redwood at middle latitudes, and these in turn disappear as fig, laurel and palm attain dominance in Central America. This change in modern forests southward we interpret as largely a response to rising temperatures. Figs may not live near the arctic circle because of the severe winters; the trees of the north can not meet competition with forest giants in the tropics. The result is a zoning of vegetation which enables a student of modern plants to estimate the approximate latitude and temperature of his position from the character of the forest. Similar zoning characterizes the forests of Eurasia as well. This must of necessity be the case if temperature is the primary factor in plant distribution, since —with certain modifications to be discussed later—temperature is a function of latitude. Fig. 1 shows the distribution of several of the major floristic units in the northern hemisphere, together with the isotherms for the winter season. This is the season most significant to our dis-

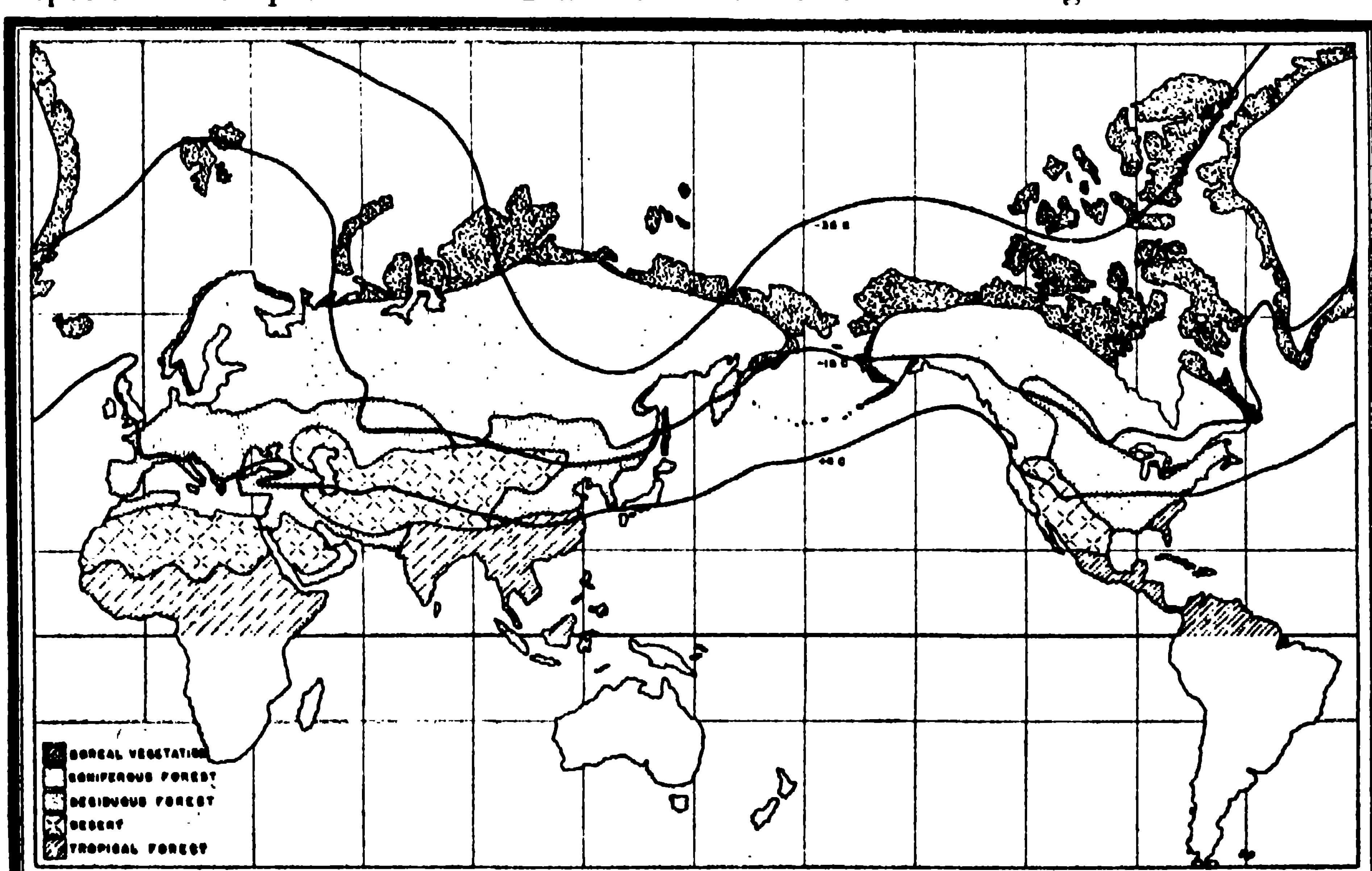


FIG. 1. DISTRIBUTION OF JANUARY ISOTHERMS AND VEGETATION IN THE NORTHERN HEMISPHERE.

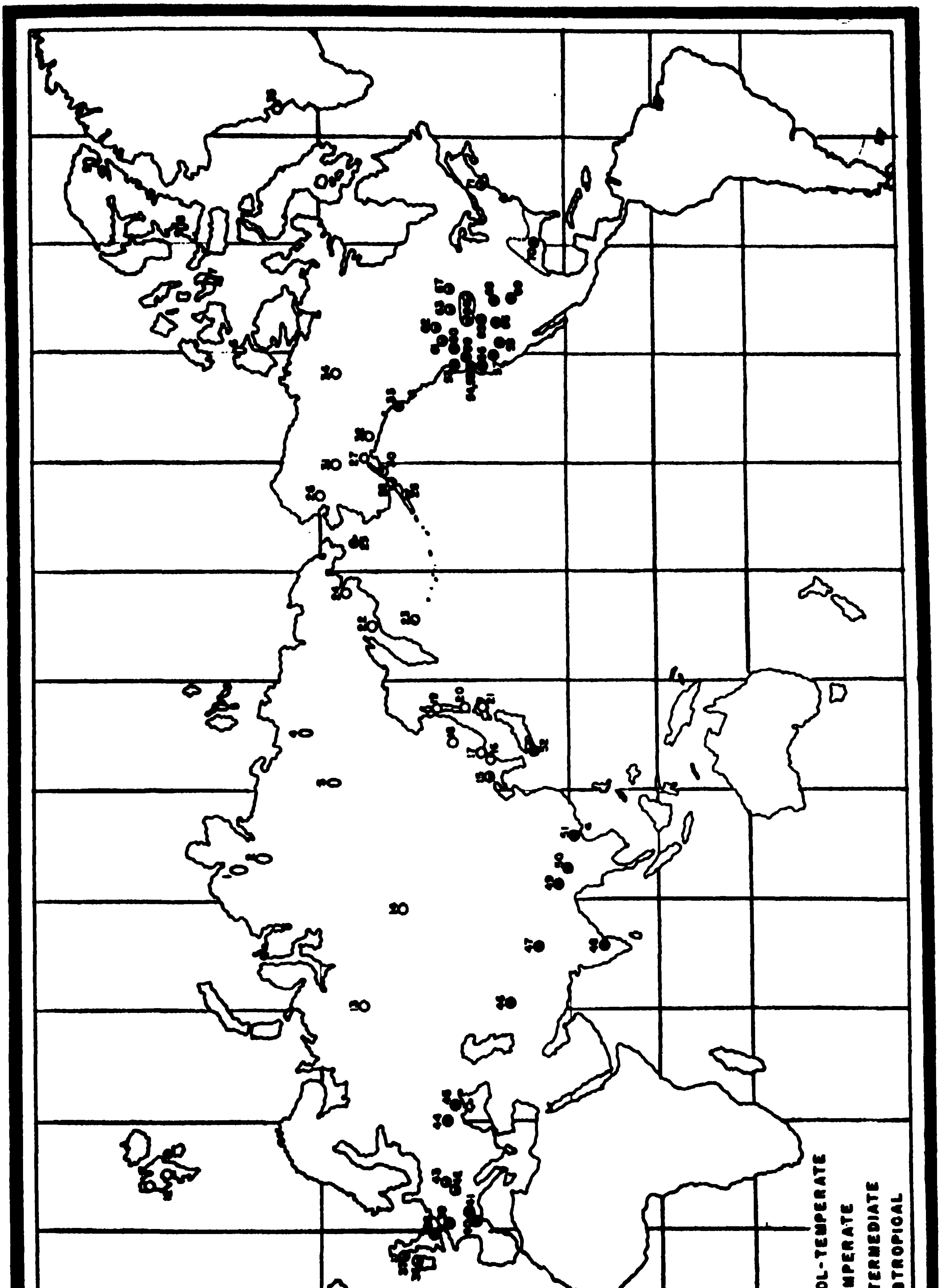


FIG. 2. DISTRIBUTION OF OLDER TERTIARY FLORAS IN THE NORTHERN HEMISPHERE.

FIG. 3. RAINFOREST OF GUATEMALA

(LATITUDE 16° NORTH.) SIMILAR TO SUBTROPICAL EOCENE FLORAS OF MIDDLE LATITUDES.

FIG. 4. FOSSIL LEAVES OF MAGNOLIA

FROM THE EOCENE FOUND IN OREGON (LATITUDE 44° NORTH). REDUCED ONE THIRD.

cussion, since minimum temperatures largely determine the northward limits of forest distribution.

The paleobotanist finds evidence that forest zoning can be traced back for tens of millions of years, to the epoch known as the Eocene. There are abundant fossil records of Eocene plants in the northern continents which make possible the reconstruction of a zone of subtropical forests, as indicated by the black circles in Fig. 2. At each of the localities so marked, there have been found leaves, fruits or stems of plants which resemble those now living in the tropics or on their borders. Some of the more common of these plants are the avocado (*Persea*), chumico (*Tetracera*), fig (*Ficus*), magnolia (*Magnolia*) and nipa palm (*Nipadites*). Their fossil leaves are relatively large and thick, like those of modern plants which live in warm regions. A slab of fossils and the modern forest containing similar living trees are pictured in Figs. 3 and 4. Our conclusion that such fossil floras indicate subtropical temperatures is based upon the assumption that plants of the past had essentially the same habitat requirements as their nearest living relatives. Single species taken by themselves would not justify such an assumption, but when most or all of the members of a fossil forest indicate warm living conditions, we may conclude with confidence that this forest lived south of the zone of winter frosts.

On our map several circles along the northern fringe of the Eocene subtropical zone are white in their northern halves. This indicates that the fossil floras which they represent were transitional in composition between subtropical and temperate forests. The latter, shown by white circles, occupied a latitude averaging 55 degrees, and were made up largely of plants which live to-day in regions where the temperature is intermediate between tropical and boreal. Some of the more common members of this temperate flora are basswood (*Tilia*), chestnut (*Castanea*), elm (*Ulmus*), hornbeam (*Carpinus*), maple (*Acer*), oak (*Quercus*), redwood (*Sequoia*), sycamore (*Platanus*) and walnut (*Juglans*). Fossil remains of these trees are found widely in Eocene deposits of Alaska, Greeland, Spitzbergen and northeastern Asia. A slab of redwood twigs is shown in Fig. 6, and adjacent to it a picture of the coast redwood forest of California.

Still farther north, where trees are now stunted or wholly absent, there are several localities where the vegetation of the Eocene was limited almost entirely to boreal plants such as birch (*Betula*), poplar (*Populus*), spruce (*Picea*) and willow (*Salix*). These are indicated by ovals on our map, and are not so numerous as in the other zones due to inadequate information regarding fossil plants in extreme high latitudes. Eocene leaves of spruce and alder from Grinnell Land are shown in Fig. 7, and Fig. 8 shows the modern Alaska habitat of similar plants. The zonation of these northern floras and of those farther south is closely similar to that of corresponding modern forests. Vegetation of a given climatic type is at approximately the same distance from the north pole in Eurasia as in North America, from which we conclude that these continents were grouped about the north pole in essentially their present position as far back as Eocene time.

A striking difference between the Eocene distribution of these floras and their present occurrence is that in every case they ranged farther north in the past. The subtropical forests, now located within 36 degrees of the equator, ranged beyond 51 degrees north latitude; the temperate forest lay 20 degrees north of the center of its modern range; and the boreal forest, extending into regions where trees no longer can live, had outposts 20 degrees north of

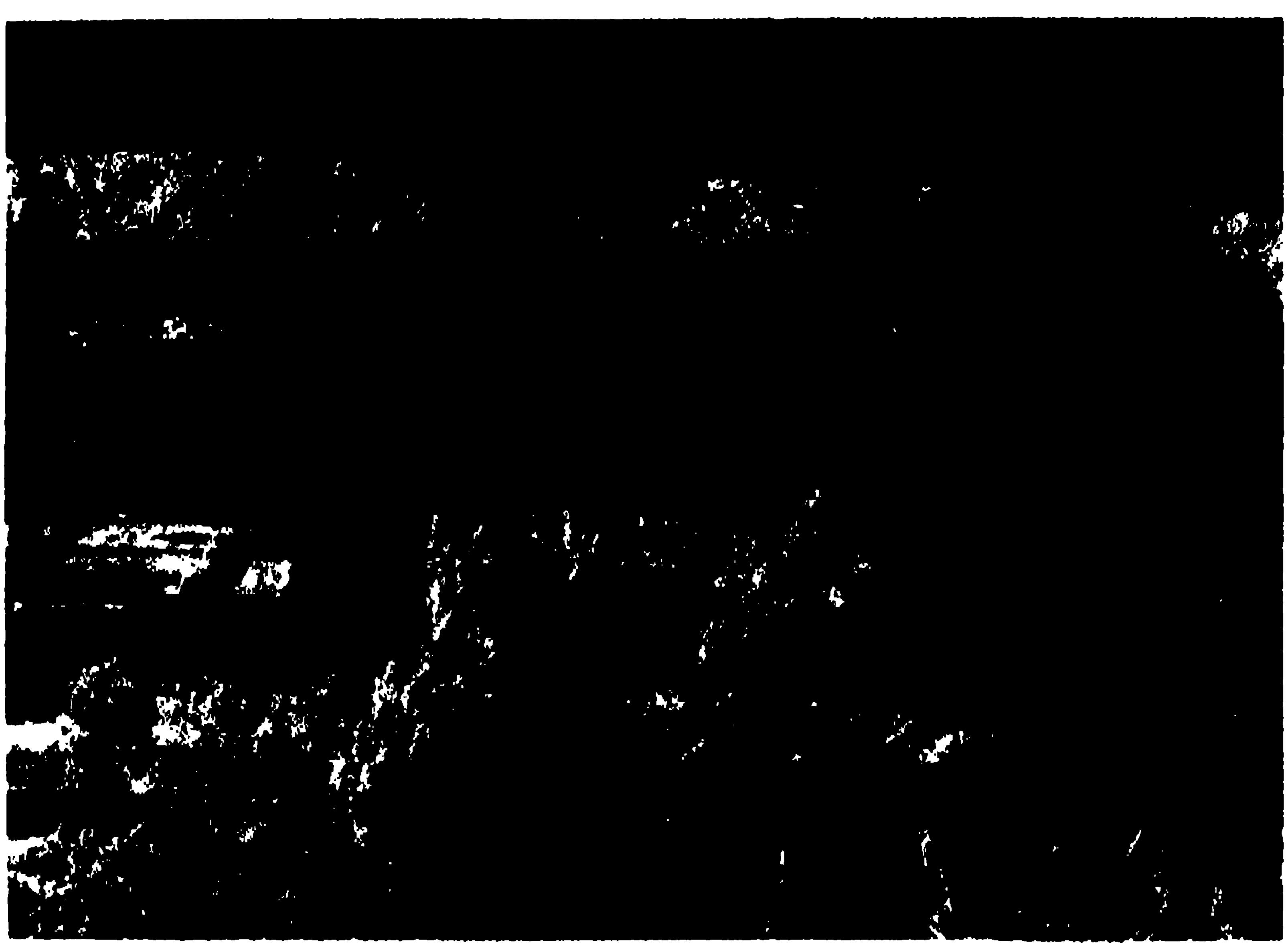


FIG. 5. CALIFORNIA REDWOODS

SIMILAR TO THOSE THAT GREW AS FAR NORTH AS THE ARCTIC CIRCLE IN THE EOCENE AGE.

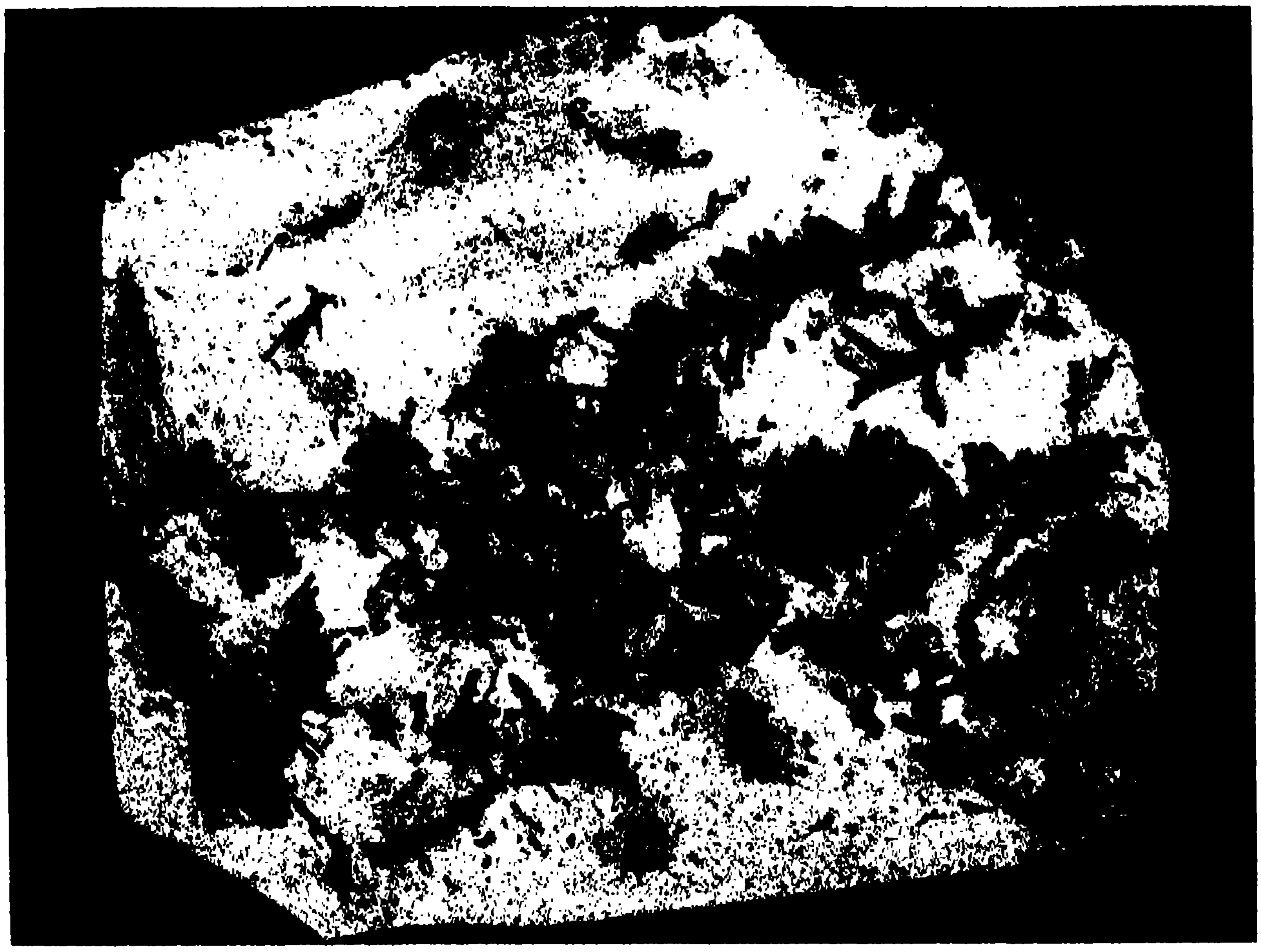


FIG. 6. FOSSIL REDWOOD LEAVES

FROM EOCENE DEPOSITS OF ST. LAWRENCE ISLAND, ALASKA, LESS THAN 200 MILES FROM THE ARCTIC CIRCLE.

the latitude in which it is best developed at the present time. The subsequent migration of these forests southward to their present positions we interpret as due to climatic change,—a gradual lowering of temperature which made it impossible for them to survive in the north. Supporting this idea of a climate becoming colder during later geologic time is the evidence of fossil shells; marine molluscs of types now characterizing warm seas ranged as far north as Alaska as shown by their occurrence there in rocks of Eocene age. Mammals to-day limited to the warmer parts of the world also lived well to the north of their present homes. It is not within the province of this paper to consider the causes of such reduction in temperature, but the fact of its change seems to be well established by the fossil record of organisms which lived both on the land and in the sea. The resulting shift of forests southward for equal distances in North America and Eurasia (see Figs. 2 and 1) indicates that as far back as Eocene time these continents were grouped around the north pole in their present relative positions. The latter point is worthy of emphasis, since the consensus of opinion among exponents of continental drift places the pole at approximately 45 degrees north latitude and 170 degrees west longitude during the Eocene. By this they do not necessarily mean that the position of the axis of rotation has been altered, but rather that the continents had a different relative position around the poles; on Wegener's map North America was turned so that the present Pacific Coast faced northward instead of westward; Europe lay off to the south, with Spitzbergen at latitude 40 degrees and Greenland at about 30 degrees. The walnuts, oaks and redwoods which make up so large a part of the fossil flora from these localities now live in comparable latitudes, and a hypothesis which has moved them northward thus meets the known facts of forest distribution during the Eocene. The subtropical floras farther south in England and France contain figs and magnolias equally well suited to the latitude 65 or 70 degrees south of the pole, as based on this concept of continental drift.

But when we come to the western hemisphere and examine the position of the corresponding North American forests, strange inconsistencies are at once apparent. The Eocene flora of Alaska would have lived only 15 degrees away from the north pole, at a latitude much too high for temperate forests if the climate as postulated was like that of to-day; the subtropical flora of Oregon would have lived about 30 degrees south of the pole, at a latitude now too severe for the best development even of a temperate flora. It is apparent that in settling the problems

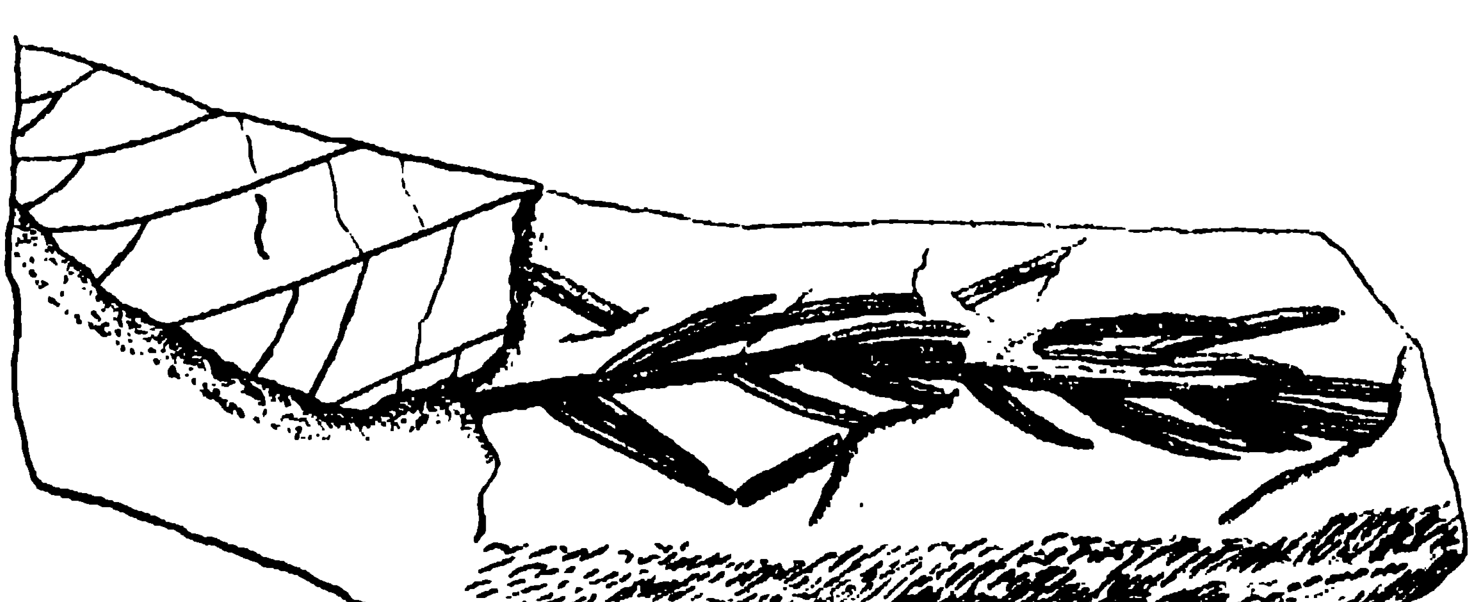


FIG. 7. FOSSIL LEAVES OF SPRUCE AND BIRCH FROM THE EOCENE OF GRINNELL LAND.

FIG. 8. MODERN TUNDRA VEGETATION OF ALASKA (LATITUDE 65° NORTH)
WITH TREES AND SHRUBS SIMILAR TO THOSE OF THE BOREAL EOCENE FLORAS.

of fossil floras on their own continent, European exponents of the theory of continental drift have condemned our American forests to retroactive frost and freezing. The character and distribution of Eocene forests in North America definitely refutes the suggestion that the northern continents have changed their positions around the pole during later geologic time. They lay in essentially the same latitudes as floras in Eurasia which contain similar or identical fossil species, and were distributed in zones governed as they now are by their distance from the existing north pole. Any explanation of changed climatic distribution since the Eocene must apply to all the continents of the northern hemisphere, rather than to a particular area selected because it seems best to fit a hypothesis.

There is an equally fundamental objection to the map of the Eocene continents as postulated in Wegener's Pangaea. As indicated above, there was no Atlantic Ocean separating North America from Europe during that epoch. In the absence of an ocean, no current like our modern Gulf Stream could have carried warm waters to the shores of Scandinavia as it does to-day. The effects of the Gulf Stream upon living forests in northwestern Europe may be seen by reference to Fig. 1. Trees which are characteristic of central Europe range northward beyond the Arctic Circle along a shore to which are brought the warm waters from the Gulf of Mexico. The northward turning of isotherms in this region is an expression of the milder air temperatures which result from this current. In the Pacific Ocean there is likewise a response to the warmer climate resulting from the Japan current, for temperate forests extend farther north along the coast of Alaska than in the interior. These relations of ocean currents to land temperatures may be summarized by stating that shores are warmer than continental interiors, especially on the windward sides of the continents and in winter. At this season isotherms turn northward over the oceans, southward over the continents, in the northern hemisphere.

It is obviously impossible to draw isotherms based on direct observation of Eocene temperatures, for weather bureaus were not functioning sixty million years ago, nor were there ships at sea to radio information regarding the oceans. But by drawing lines known as isoflors we may approximate the positions of Eocene isotherms. These lines connect floras of the same general composition, which are assumed to indicate, as do similar floras to-day, essentially the same climatic background. The isoflor connecting the localities where subtropical floras have been recorded, as shown by Fig. 9, swings up the west coast of Europe into England, then turns southward into France and trends in a southeasterly direction, with a bulge north over the Black Sea, across Eurasia to the coast of central China. Here it turns northward along the coast of Japan, reaching the coast of western America in Washington and Oregon, swinging southeastward to Tennessee, and thence north across the Atlantic to the British Isles. The Eocene isoflor connecting temperate floras likewise swings far to the north on the western coast of Europe to Spitzbergen, thence southward across Russia to Korea and southern Siberia, turning northward around the shore of the Pacific to Alaska, trending southeasterly across Canada, and northward again in the Atlantic on both sides of Greenland. Fewer fossil localities are available for the boreal isoflor, but it also swings northward over oceans and southward across continents. So closely do the Eocene isoflors correspond in position to the modern winter isotherms of the

northern hemisphere that we may assume they have essentially the same significance as indicators of minimum temperatures. And since they swing northward over the oceans as now constituted, southward over the continents as we know them to-day, we are forced to the conclusion that these ocean basins and continental platforms must have stood in essentially their present positions as far back as Eocene time. Again there is direct contradiction of the hypothesis that the northern continents have moved since the Eocene, and that the Atlantic basin has resulted from the gap formed by the cleavage of the New World from the Old. There must have been an Atlantic Ocean between North America and Europe at the time our fossil forests were living, else why should we have evidence of an Eocene equivalent of the Gulf Stream in the northward turning of the isoflors between Greenland and Scandinavia? Plotting the Eocene fossil plant localities on Wegener's Pangaea, the isoflors would have run in a nearly north-south direction rather than in parallel lines around the poles as do isotherms to-day, and as isotherms must always have run if heat from the sun has been the controlling factor in earth temperatures and plant distribution.

We conclude that the evidence of Eocene floras, made up of close relatives of living trees whose climatic requirements are well known, strongly refutes the hypothesis of continental drift during later geologic time. The question of drift at an earlier date in earth history must be answered by reference to the nature and distribution of plant fossils in older rocks, and need not be considered here. But for tens of millions of years, since life on the earth has been similar to that of to-day, North America and Eurasia have occupied their present position with relation to the north pole and the ocean basins. During this latest chapter of life history, forests have migrated southward in response to changing climate, over conti-

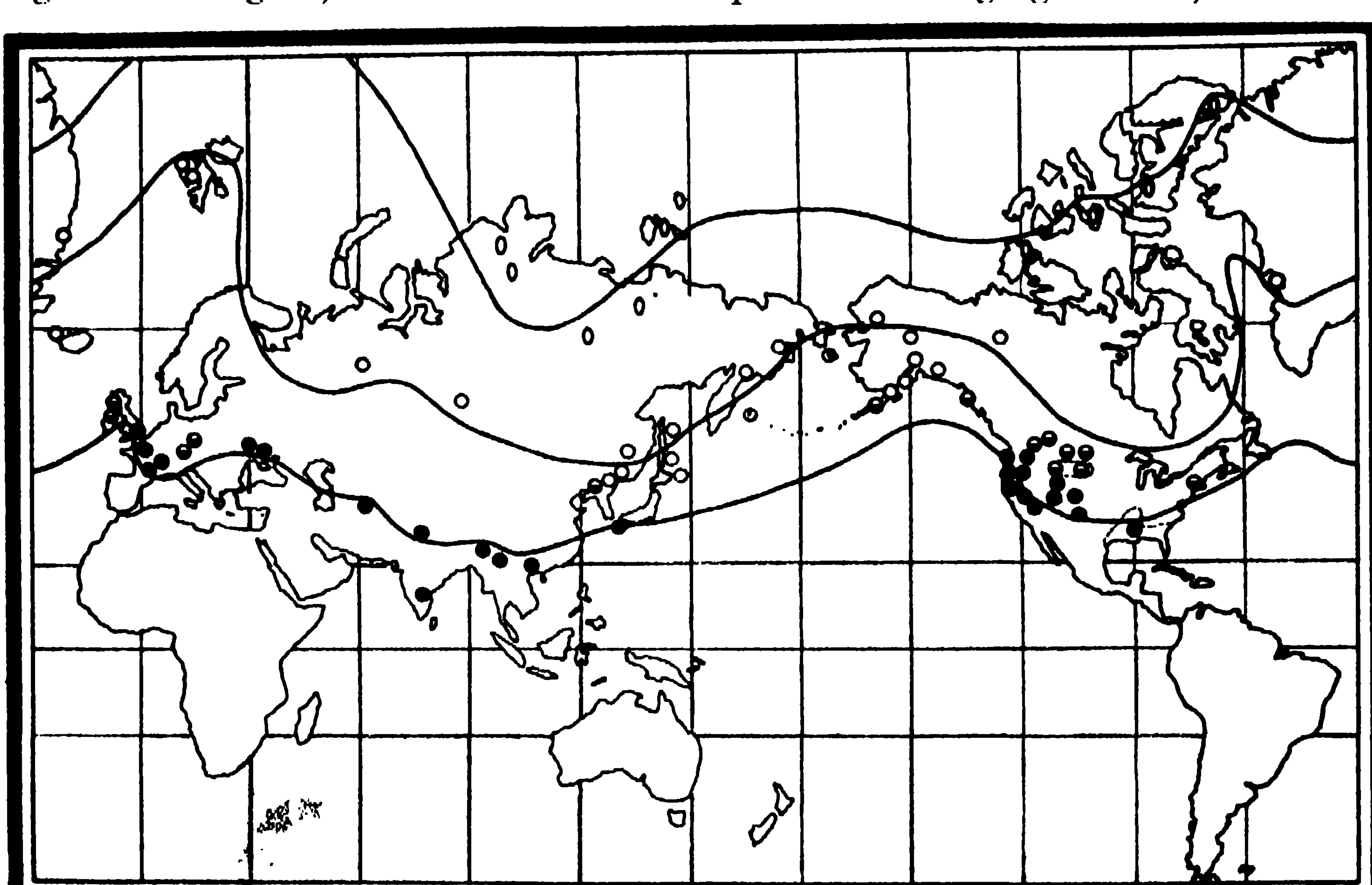


FIG. 9. DISTRIBUTION OF EOCENE ISOFLORS IN THE NORTHERN HEMISPHERE.

nents whose stability through the ages seems well established.

List of Older Tertiary Localities or Formations
(Shown on Fig. 2)
Cool temperate

(1) Taimyr River, Siberia; (2) Boganida River, Siberia; (3) Tschirmyi, Siberia; (4) Tas-takh Lake, Siberia; (5) New Siberia Islands; (6) Banks Island; (7) Bathurst Island; (8) Ellesmere Island; (9) Grinnell Land.

Temperate

(10) Iceland; (11) Sabine Island, Greenland; (12) Spitzbergen; (13) Lozva River, Siberia; (14) Simonova, Siberia; (15) Fushun, Manchuria; (16) Kisshu-Meisen and Ryudu, Korea; (17) Possiet Bay, Siberia; (18) Khabarovsk, Siberia; (19) Dui, Sakhalin; (20) Naibuchi, Sakhalin; (21) Shitakara and Ishikari, Hokkaido, Japan; (22) Korf Gulf, Siberia; (23) Commander Islands; (24) Anadyr River, Siberia; (25) St. Lawrence Island; (26) Kobuk River, Alaska; (27) Eska Creek, Alaska; (28) Chignik, Alaska; (29) Cape Douglas, Alaska; (30) Port Graham, Alaska; (31) Central Yukon Valley, Alaska; (32) Berg Lake, Alaska; (33) Kupreanof Island, Alaska; (34) Great Bear River, MacKenzie; (35) Atanekerdluk, Disko Island, Greenland.

Subtropical

(36) Antrim County, Ireland; (37) Isle of Mull, Scotland; (38) London Clay, England; (39) Paris Basin, France; (40) Celas, France; (41) Sezanne, France; (42) Bavarian Alps; (43) Jesuitengraben, Bohemia; (44) Kiev, Ukraine; (45) Elisabethgrad, Ukraine; (46) Eroilan-duz, Turkestan; (47) Kasauli, India; (48) Deccan Plateau, India; (49) Assam, India; (50) Burma, Further India; (51) Na-giao, Indo-China; (52) Takashima, Kyushu, Japan; (53) Steel's Crossing, Washington; (54) Comstock, Oregon; (55) Goshen, Oregon; (56) Ashland, Oregon; (57) Weaverville, California; (58) Chalk Bluffs, California; (59) Clarno, John Day Basin, Oregon; (60) Swauk, Washington; (61) Calgary, Alberta; (62) Red Deer River, Alberta; (63) Upper Ravenscrag, Saskatchewan; (64) Fort Union, from Yellowstone Park to South Dakota; (65) Wind River, Wyoming; (66) Green River, Wyoming; (67) Roche Percee, Saskatchewan; (68) Denver Beds, Colorado; (69) Raton, Colorado and New Mexico; (70) Wilcox, Claiborne and Jackson, southeastern United States; (71) Brandon, Vermont.

STUDENT TRAINING AND NATIONAL DEFENSE

I agree with what I understand to be the view of the Army and Navy, that military training is best conducted by the Army and Navy in their own establishments. The university may train people in highly specialized work for which the Army and Navy have no facilities or personnel. It may offer incidental opportunities to its students to gain some elementary military knowledge, provided such activities do not interfere with their education. Beyond these kinds of effort the colleges and universities should leave military training to the military forces and devote themselves to giving their students, while they have them, the best education they can. Military training and education, at the university level, do not mix. The Army and Navy are much better qualified to give military training than the universities, the universities are much better qualified to give education than the Army and Navy. We shall get the best results if each group confines itself to the field of its special competence.

I also agree with the views expressed by Mr. Roosevelt, who has said, "Young people should be advised that it is their patriotic duty to continue the normal course of their education unless and until they are called, so that they will be well prepared for greatest usefulness to their country. They will be promptly notified if they are needed for another patriotic service." I go so far as to favor the prohibition of volunteering, on the ground that it interferes with a program of putting the right man in the right place and permits hysteria and social pressure to determine the course of many young people.

On the other hand, I do not favor any exemptions from the draft for college and university students as such. Each man called should be put at that work contributing to national defense for which he is best qualified. If he will be most useful to his country receiving specialized training at a university, he may be assigned to work there, or his military service may be deferred until his training is completed. But nothing would be worse for higher education in this country than to have it thought that enrolment in a college or university is a method of avoiding conscription.—*Report of Dr. Robert M. Hutchins, president of the University of Chicago, to alumni and friends of the university.*

SOME ASPECTS OF CENTRAL AMERICAN BIRD-LIFE

II. PLUMAGE, REPRODUCTION AND SONG

By Dr. ALEXANDER F. SKUTCH

SAN JOSÉ, COSTA RICA

IV

Seasonal changes in the coloration of the same individual bird are a phenomenon in the bird-life of the North Temperate Zone so familiar that we are apt to look upon it as a characteristic of birds in general. I had already devoted some years to the study of Central American birds before it dawned upon me that I did not know one single instance of seasonal change in coloration among the resident species. Since then, keeping this problem especially before me during the course of seven years, I have convinced myself that a seasonal change of coloration does occur only in a single species of finch, the far-ranging blue-black grassquit (*Volatinia jacarini*). The plumage of the males among these little birds of grassy places, shining blue-black during most of the year, is clouded with brown during its closing months—yet even then a few individuals in full breeding plumage will be seen. I at one time considered these brownish males to be young individuals moulting into the adult plumage; but in certain districts, in December, they form far too great a proportion of the entire male population for this view to be tenable. Careful and continued watching of many species in the field has failed to bring to light another convincing example of seasonal change in attire among the inland birds of Central America, although a comparison of specimens collected at various seasons might reveal changes too slight to be noticed in the free, living birds.

The semi-annual change in array seems to be a phenomenon somehow linked with the habit of migration. Not that all migratory birds, even those brightly colored, exhibit it, or all non-migratory birds fail to manifest it—this is far from being true. Yet many facts, some of them concerning the most familiar birds, are so suggestive of a relationship—by no means a simple and direct one—between migration and seasonal plumage-change, that students of birds can not afford to disregard them. Is it merely a matter of chance that the brilliant red male cardinal, a non-migratory species, wears the same plumage amid winter's snow and summer's verdure, while the bright indigo bunting, cardinal's neighbor during the summer months, is far more plainly attired while in his winter home far away? The critical reader will object that the painted bunting, certainly no less splendid in his parti-colored array than his close relation, the indigo, is clad in the same colors the year around, in spite of his migrations. But the painted bunting performs shorter migrations; and some may linger over the winter in southern Florida: facts which suggest that the migratory urge is weaker in this species than in the indigo bunting. Turning to a different family, is it merely a matter of chance that the migratory summer tanager wears the same bright red plumage in his winter home in Central America and his summer home in southern United States; while the scarlet tanager, which performs a much longer annual journey, changes the intensely brilliant cloak of scarlet and black that

he wears in northern United States for a far less colorful dress during his sojourn in South America? Is it a purely fortuitous coincidence that the bobolink, the greatest traveler in the oriole family (Icteridæ), undergoes the most complete seasonal changes in coloration to be found in that great family, most of whose members are non-migratory? These examples and a number of others that might be cited suggest the possibility of a quantitative relationship between extent of migration and annual change in coloration; but at the same time their diverse character serves to warn the student that this problem is by no means a simple one, and that almost any generalization he may dare to arrive at must be followed by a list of exceptions.

The seasonal changes of coloration of migratory birds can not, in most cases, be explained by the necessity of diverse color-patterns to make the same individual inconspicuous in the different environments of its winter and summer homes. In the first place, birds as a rule seek the same type of habitat in their wintering as in their breeding range, those which live in the forest in the North seeking forest in the South, those which breed in grassland passing the winter in grassland, and those which prefer low, tangled thickets frequenting such vegetation the year about. The red summer tanager is neither more nor less conspicuous among the foliage of a Costa Rican forest composed of a hundred species of trees than in a northern forest of half a dozen kinds; and his enemies are no more numerous in his winter home. Secondly, diurnal, arboreal birds, in my experience, depend little if at all for their personal safety upon "protective coloration," their ability to escape detection; rather they stake their lives upon their alertness and fleetness. At the nest, on the contrary, the parent's ability to avoid detection may mean the difference between life and death, not for the mobile parent, but for the immobile occupants of the nest. How many a nest, which otherwise would most probably have been

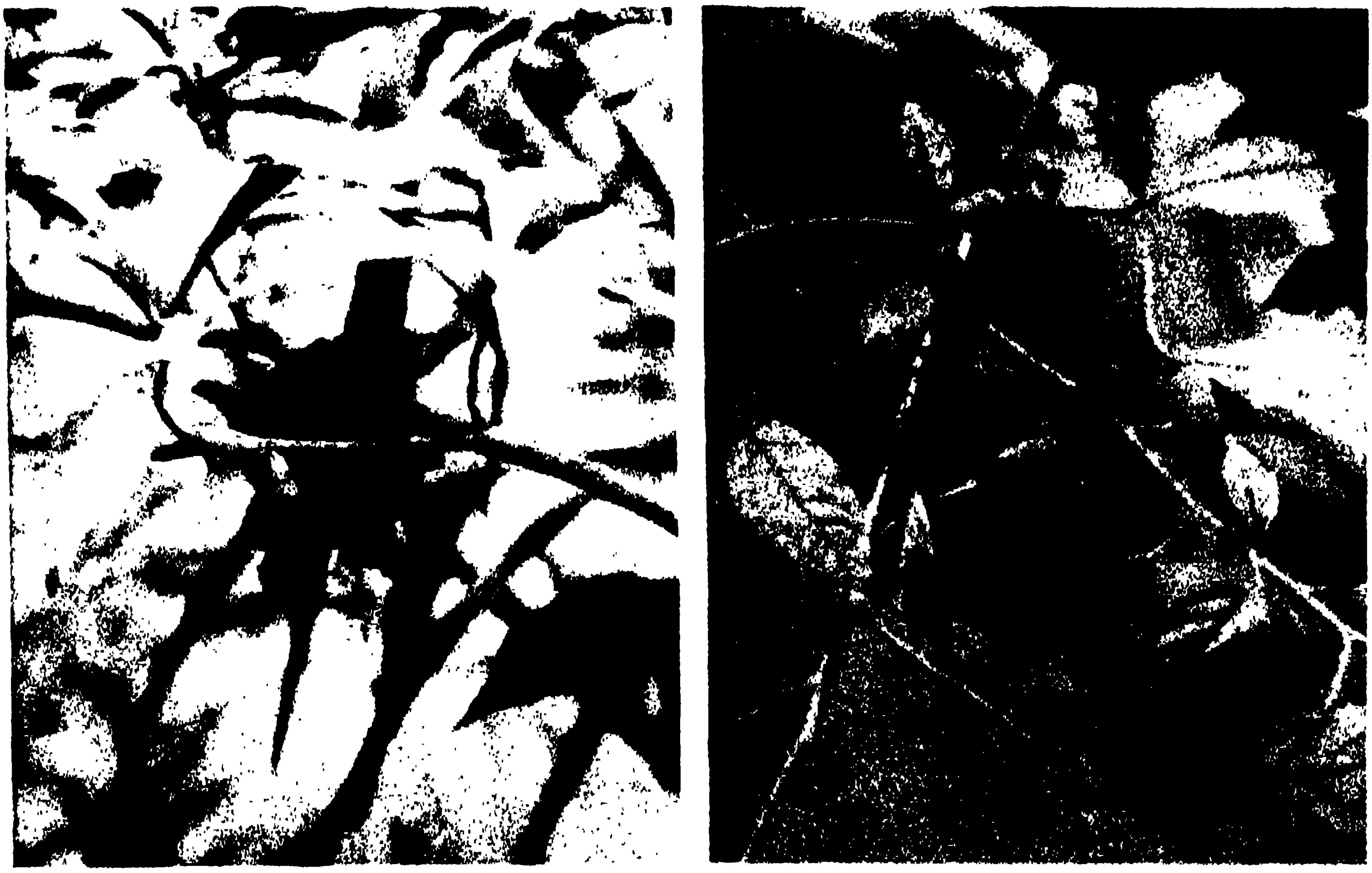
VOLCÁN SANTA MARÍA (ABOUT 12,400 FEET)
PHOTOGRAPHED FROM THE PLATEAU NEAR QUEZALTENANGO, GUATEMALA

overlooked, has been revealed to me by the parent bird's abrupt departure!

Closely allied to the questions we have been discussing is that of the differences in coloration of the male and female of the same species. In eastern North America, so many of our brilliant male birds have soberly colored mates that we come to consider this as the natural order of things among feathered beings. But the situation is quite different in Central America. Among the highly migratory wood warblers of temperate North America, the male, if at all gaily attired, has a mate of duller plumage. But among the non-migratory warblers of Central America, many of which remain paired through the year, the sexes are alike in plumage more often than not. This is true of such typical genera as *Myioborus, Basileuterus* and *Ergaticus*, species of which are among the most beautifully attired of warblers. Again, among the highly migratory orioles (*Icterus*), a striking difference in coloration of male and female is the rule; but among the non-migratory Central American orioles, no less brilliant in their splendid array of gold and black than their migratory cousins, the sexes are alike or only slightly different in coloration. Among the Central American finches, it is noteworthy that none of the numerous species which I have listed as remaining mated through the year exhibits sexual differences in coloration; while those which aggregate into large flocks after the close of the nesting season (chiefly the seed-eaters, grassquits and goldfinches) show pronounced sexual differences in plumage. The same holds true of the tanagers. In the genera *Thraupis, Tangara, Calospiza* and *Calliste*, containing some of the most lovely and gem-like of Central American birds, those species best known to me commonly fly two by two at all seasons, except when accompanied by young dependent upon them for support; and male and female are exactly or essentially alike in plumage. On the other hand, in such genera of beautiful birds as *Euphonia, Chlorophonia* and *Ramphocelus*, which form conspicuous flocks (certain species of *Ramphocelus* being polygamous by excess of females), sexual differences in coloration are most conspicuous. Among the typical honeycreepers, *Cyanerpes* and *Dacnis* travel in flocks and the sexes are very different in appearance; *Cœreba* never flocks, possibly remains paired, and the sexes are identical.

Thus among migratory song-birds, the male, if brighter than his mate during the breeding season, frequently, but by no means invariably, assumes a plumage more like hers after its close. On the other hand, among the non-migratory song-birds of tropical America, especially those which live in pairs through the year, there is a strong tendency for the female to wear a dress quite as bright as the male's; and both retain their colorful attire at all seasons. If we seek a common causative agent which may unify things seemingly so diverse as migration, seasonal changes in plumage, sexual differences in plumage, and the habit of remaining paired through the year, it seems likely that this agent may be found in the internal secretions of the organs of reproduction. We know, on the one hand, that these exert a strong influence upon the migratory urge, and on the other, that they are responsible for the sexual differences in plumage.

Intimately linked with the subjects of sexual and seasonal diversities in plumage in the same species is that of the age at which the young bird acquires the coloration of the adult. Among the species of temperate North America which exhibit pronounced sexual, and frequently seasonal, differences in coloration, the young males as a rule pass their first winter in a dress closely similar to that of their



BIRDS OF LOWLAND RAIN-FOREST IN PANAMA
Left: FEMALE RED-HEADED MANAKIN (*Pipra mentalis*) ON NEST. *Right:* FEMALE SLATY ANT-SHRIKE (*Thamnophilus punctatus*) ON NEST.

mother, and acquire the bright nuptial dress at the outset of their first nesting season, by means of the prenuptial moult. But in many kinds of Central American birds, of which the sexes are alike, I have observed that the young, decidedly different from their parents at the time of quitting the nest, promptly change into the brighter plumage of the adults, by means of the postjuvenal moult. Without the retarding influence of winter, or of migration, the youngsters acquire the bright adult dress far earlier than their cousins of "temperate" regions. In quite a number of species of Central American finches, warblers, tanagers, mockingbirds, wrens, etc., a few months after the close of the breeding season, young and old, males and females, are alike, or at least confusingly similar, in appearance.

In the species of which male and female are distinct in plumage, the young males, at first resembling their mothers, may assume the colors of their fathers at their first (postjuvenal) moult. Or, less frequently, they may wear a dull or intermediate plumage for a year or more, even breeding in it, as occurs among Central American birds in the yellow-crowned euphonia, the Costa Rican chlorophonia, some of the more deeply colored thrushes of the genus *Turdus* and certain manakins. The situation is exactly paralleled in such northern birds as the orchard oriole and the purple finch.

V

It has long been known to students of birds that the nests of tropical species commonly contain fewer eggs than those of the most closely related kinds of higher latitudes. Of the thousand nests of hundreds of species of Central American birds into which I have peeped, not one has held more than five eggs, excepting only those of the anis, which build com-

SUBTROPICAL RAIN-FOREST IN COSTA RICA

HEADWATERS OF RÍO SARAPIQUÍ (5,000 FEET). IN THE HAUNTS OF THE BELL-BIRD, QUETZAL, SOLITAIRE, TOUCANET AND BARBET.

munal nests that cradle the offspring of several closely coöperating pairs. Two is the number of eggs most commonly found in the nests of Central American birds, including a great number of finches, tanagers, honeycreepers, flycatchers, manakins, antbirds, hummingbirds, doves and others too numerous to mention. Sets of three are by no means rare, of four less common, and of five distinctly uncommon. I have found so many only rarely, in the nests of cactus wrens, swallows, a kingfisher and a few others. A single egg forms the full set in the nests of certain pigeons of the genus *Columba.*

The fact that a certain bird lays smaller sets of eggs than another is not proof that it raises fewer offspring during the course of a year; it may compensate its smaller sets by a greater number of broods. It is important to learn whether Central American birds actually produce fewer offspring than the feathered kind farther to the north, or whether a longer breeding season, made possible by a tropical climate, offsets the smaller size of individual broods.

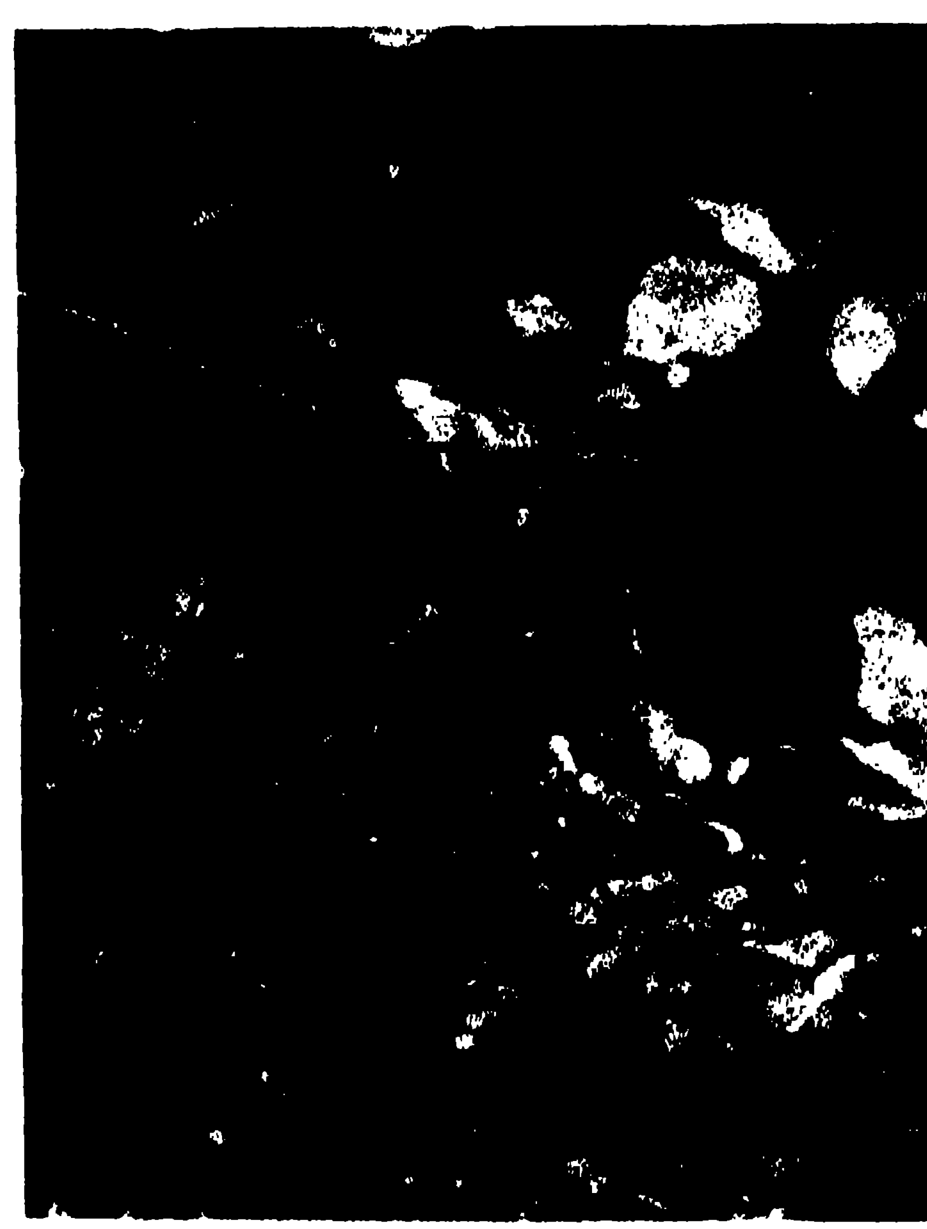
A few exceptional species, including Rieffer's hummingbird (*Amazilia tzacatl*), the ruddy ground dove (*Columbigallina rufipennis*) and the slaty antshrike (*Thamnophilus punctatus*), nest, in the Caribbean lowlands, *as species,* throughout the year. It is not known over how long a period the reproductive activities of a single individual may extend; but it is almost inconceivable that she should breed continuously. Each of these species lays regularly only two eggs in a set; of the three, the reproductive cycle of the antbird is slightly shorter than the others; if we set it at forty days, and assume that a pair breed continuously without a rest through the twelve months, they could raise at best nine broods, or eighteen fledglings, in the course of a year. Yet even admitting this highly improbable result, the antbirds could not equal the record of the English robin, which may lay eight eggs in a set, and is said to produce a maximum number of twenty in a single summer! The highest fecundity among Central American birds actually known to me by direct observation is that of a pair of house wrens (*Troglodytes musculus*), which between December and June laid four sets of four eggs each, in a gourd which I put up for them in southern Costa Rica, and successfully raised at least one fledgling in each brood.

There is good evidence from a number of sources that Central American birds lay fewer eggs in the course of a year than those farther to the north. Thus kingfishers raise only a single annual brood in Central America, as in temperate North America; but the tropical species lay sets only about half as large as those of the northern belted kingfisher. Many kinds of tropical birds which raise a single annual brood lay only two or three eggs in a set. Although, as we have seen, a few species breed throughout the year, and in the lowlands nests of one species or another are to be found in each of the twelve months, the breeding of the birds as a whole is a distinctly seasonal activity; and the great majority of them raise their families during the quarter-year between the vernal equinox and the June solstice. In the highlands, above five thousand feet, the concentration of nests within this period of three months is even more pronounced than in the lowlands. In the mountains of Guatemala, between eight and nine thousand feet above sea-level, I found that nearly all the birds (hummingbirds and honeycreepers excepted) nested in the brief period of most favorable weather between the last frost, at the beginning of April, and the advent of the rainy season in the middle of May. Most species raised only a single brood, no larger—sometimes

smaller—than that of the most closely related birds of the lowlands where the breeding season is longer, and notably smaller than the families of birds of higher latitudes.

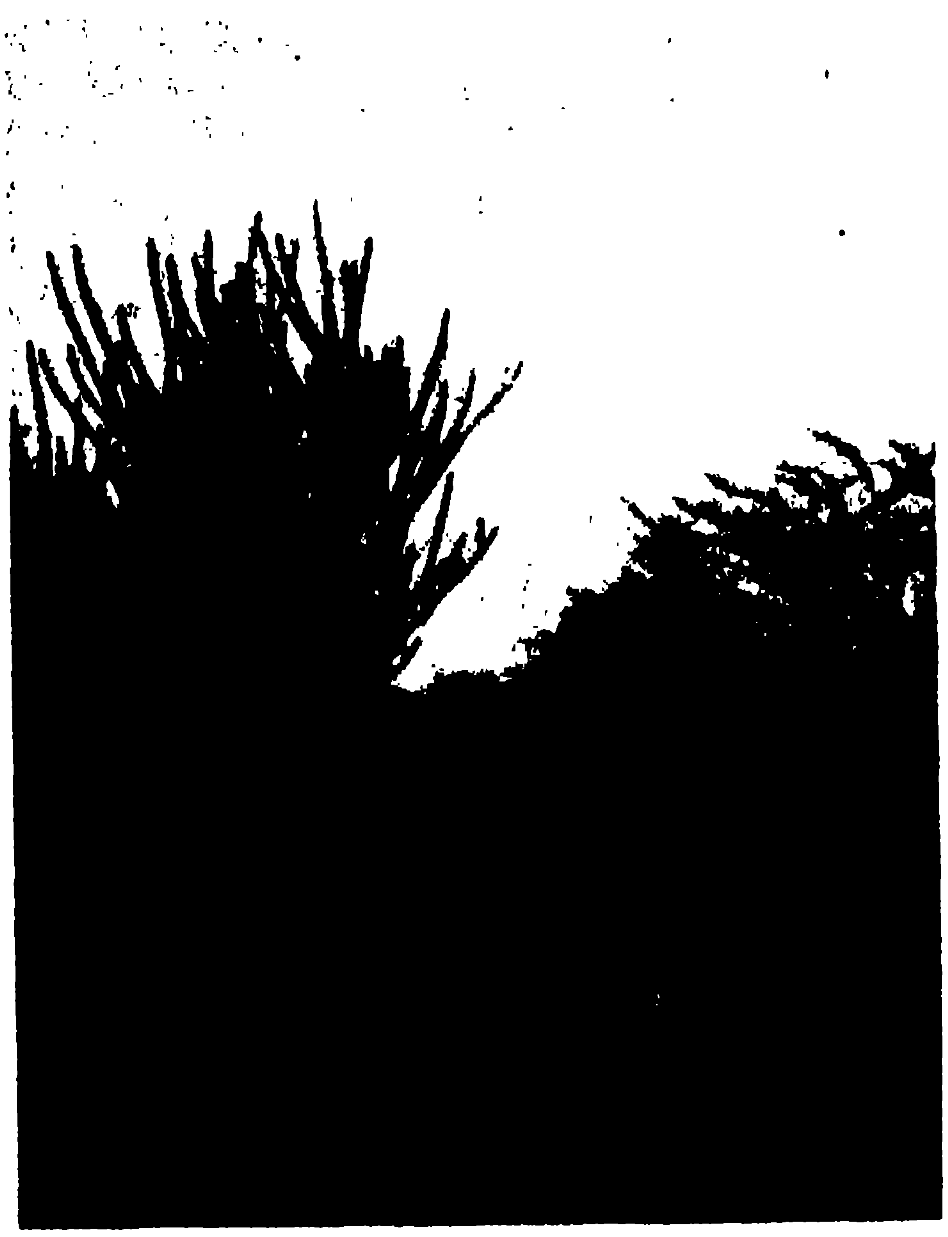
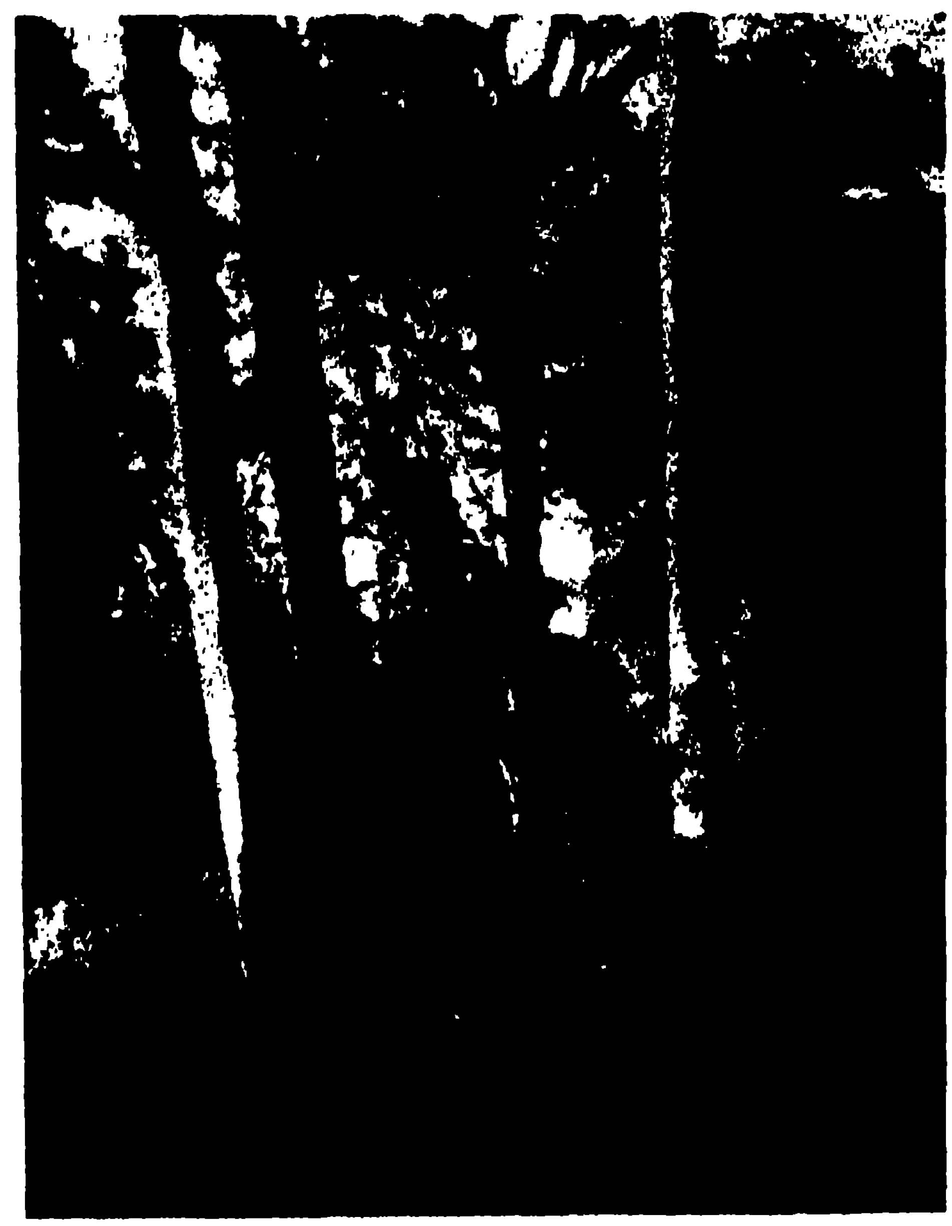
But not only is the potential number of offspring, produced each year by a pair of Central American birds, small in comparison with that of northern species; the actual number of offspring is smaller still. In the high mountains of Guatemala, 55 per cent. of the nests which I had under observation produced at least one living fledgling; on a great banana plantation in the lowlands of the same country, 43 per cent. of my nests terminated happily; in a region of southern Costa Rica where somewhat less than half the forest remained standing, the percentage of successful nestings was reduced to 33; in heavy lowland forest in the Canal Zone, only 14 per cent. of my nests—one out of seven—escaped premature destruction. This astounding mortality of nests in the lowland forests I attribute chiefly to snakes; but there are many other predators. The big Swainson's toucans are insatiable nest-robbers; the graceful swallow-tailed kites pluck many an egg and nestling from exposed nests in the tree-tops; and I suspect that monkeys, violently swaying the boughs as they career wildly through the heights of the forest, must shake not a few eggs from frail and shallow nests such as are built by a number of the woodland birds—in addition to those devoured by the carnivorous Cebus or white-faced monkey.

Because of the tremendous loss of nests, I know few endeavors more discouraging than that of trying to obtain complete life-histories of the birds of the lowland forest. Happy the bird-watcher who can discover a pair of these forest-dwellers



NESTS OF CENTRAL AMERICAN FLYCATCHERS

Left: COZY NEST OF THE BENT-BILLED FLYCATCHER (*Oncostoma cinereigulare*). *Right:* RETORT-SHAPED NEST OF THE GRAY-HEADED FLYCATCHER (*Rhynchocyclus cinereiceps*). IT IS MADE OF FINE BLACK FIBERS AND ENTERED BY FLYING VERTICALLY UPWARD INTO THE END OF THE DOWNWARDLY POINTING TUBE AT THE LEFT.

CONTRASTS OF VEGETATION IN GUATEMALA

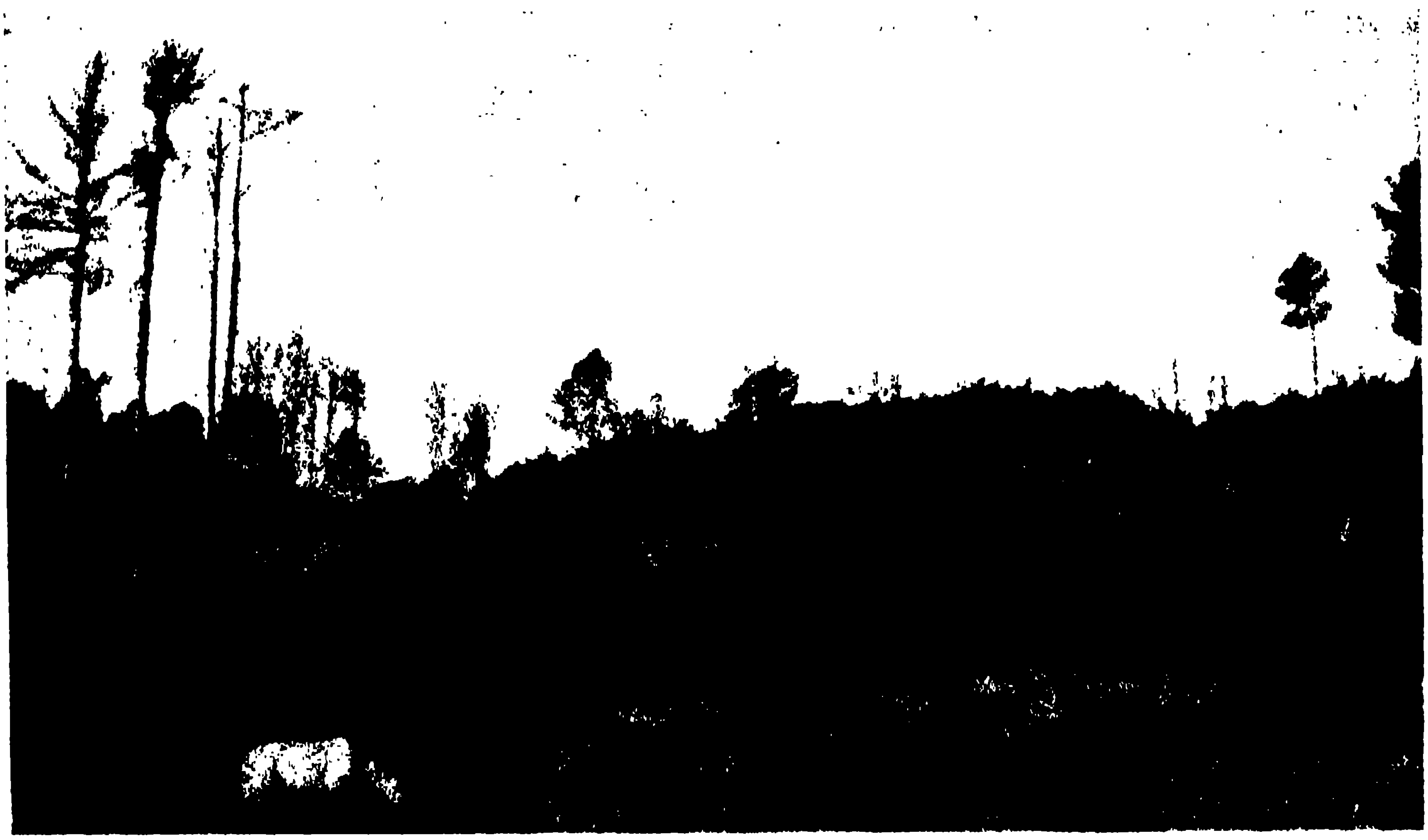
Left: CACTI AND THORNY SCRUB ON THE PLAINS OF ZACAPA (500 FEET). THE HOME OF THE MAGPIE-JAY, TURQUOISE-BROWED MOTMOT, WHITE-LORED GNATCATCHER AND LICHTENSTEIN'S ORIOLE

Right: FOREST OF CYPRESS WITH UNDERGROWTH OF BAMBOO (9,500 FEET). THE HAUNT OF THE GOLDEN-CROWNED KINGLET, BROWN CREEPER, MEXICAN TROGON, GUATEMALAN ANTPITTA AND GUAN.

who have come into a neighboring clearing to build their nest, for here their chances of success are somewhat greater—a fact of which the birds themselves seem to be aware.

Of late years, I have derived one most consoling thought from the many nests I have seen meet disaster. If the birds have such great difficulty in reproducing their kind, yet their number remains substantially constant from year to year, it follows that the adults must lead lives longer, and doubtless happier, than in regions where they succeed in raising large families, yet fail to become more numerous. My whole experience with Central American birds strengthens this deduction that their lives are, for birds, long and tranquil. Although I have upon countless occasions returned to a nest only to find that it had been emptied of its contents during the twenty-four hours since my previous visit, rarely indeed have I found evidence that either of the parents shared the unhappy fate of their offspring. In most cases where I devoted particular attention to the pair, I soon after found them hopefully preparing to nest once more. Although I have all too often had the disturbing experience of seeing a serpent devour nestlings or eggs, never once have I known a snake to catch an adult wild bird. Stories of snakes "charming" birds are admitted by most competent naturalists to be pure fable.

Central American hawks, although numerous in species, are for the most part rare in point of individuals. Many of these birds of prey seldom if ever devour smaller feathered creatures; and some, such as the guaco or laughing hawk (*Herpetotheres cachinnans*) are among



ALPINE MEADOW IN THE HIGHLANDS OF GUATEMALA

SCATTERED PINE TREES AND COPSES OF JUNIPER ON THE HIGH PLATEAU OF THE SIERRA CUCHUMATANES (10,600 FEET). HERE LIVE THE RAVEN, GUATEMALAN FLICKER, BLUE-CRESTED JAY, GUATEMALAN JUNCO, MEADOWLARK AND FLOWER-PIERCER

the very best friends the birds have, for they subsist almost entirely upon snakes, and so rid the smaller birds of the most relentless destructors of their nests. During the last six months, passed entirely in the field of southern Costa Rica, I have seen just one bird fall prey to a hawk: a swallow snatched in the fading light of evening from a vast migratory cloud of its kind. This single capture of a small bird by a hawk in the course of half a year about represents the average of my experience over a decade. The Central American hawk, apparently most destructive of bird-life, is one of the smallest, the swift, fierce-hearted, little white-throated bat falcon (*Falco albigularis*), which I have known on reliable evidence to carry off a blue-throated toucanet almost as big as itself, and which captures many smaller birds as well as large insects—but I have never known it to eat one of the bats for which it is named.

Bird-protection in the Central American countries is indeed in a lamentable state of neglect; and in the more populated districts, what with bird-trappers, small boys with sling-shots and larger ones with firearms, the feathered folk lead a precarious existence. But it should be remembered that the great Central American isthmus is chiefly wild, sparsely inhabited territory; it is in such country that I have preferred to live, and of such that I write. Here, with an abundance of food the year about; with a temperature never long below the freezing point, even on the highest peaks; with few feathered enemies, and their swiftness and alertness to prevent their falling into the clutches of other sorts; with perfect familiarity with the territory in which they reside the year round, and with its dangers; the tropical birds, having attained maturity, live far more securely than those of lands nearer the poles, and need produce fewer offspring each year

in order to maintain their population at its normal level.

The conditions of life of birds of higher latitudes are quite distinct. Each year they are faced with two alternative courses of action, both fraught with immense danger: they must either remain in the north during the cold months, or migrate southward. If they follow the former course, they may succumb to the combined effects of low temperature and insufficient nourishment; and many fall victims to predators whose hunger is sharpened by scarcity of food. The dangers which beset migrating birds, the storms which sometimes destroy them in vast numbers, the perils of a too early return in spring, the risk of impinging fatally upon some high obstruction while flying blindly through the darkness, are too well known to need description here. But one point in which migrating birds are at a disadvantage, as compared with the birds resident in the region through which the former are passing, has never, to my knowledge, been adequately stressed: The resident knows every source of danger peculiar to its district, and is perfectly familiar with the covers that afford the best security; the transient wanderer is unfamiliar with local conditions, and therefore more likely to meet disaster. It is easy to understand the urgent necessity of birds of the far north to raise large families during the brief summer months, to repair the losses their kind has suffered during the past winter.

Finally, the resident birds of Central America have time to build nests of a size, complexity and degree of comfort such as no migratory bird of high latitudes could afford to undertake. Many tropical birds are content with simple, easily constructed nests; simplicity of design seems to be the rule of architecture among finches, tanagers, antbirds and manakins. But other kinds, less readily satisfied, construct large or complex edifices for the accommodation of their young. One thinks of the great, elaborately designed and furnished castles of sticks built by the little spine-tails (*Synallaxis*) no bigger than wrens; of the commodious, often memorably beautiful pendent nests made by some of the tropical flycatchers, a family second to none in the diversity and complexity of its architecture; of the

WIDE-RANGING BIRDS

OF THE TROPICAL AMERICAN LOWLANDS. *Upper:* FLEDGLING RINGED KINGFISHER (*Megaceryle torquata*) *Lower:* NEWLY HATCHED CUYÉOS OR PARAQUES (*Nyctidromus albicollis*), RELATIVES OF THE WHIP-POOR-WILL AND THE NIGHTHAWK

long, swinging pouches skilfully and laboriously woven of fibrous materials by oropéndolas, caciques and many of the orioles. Nothing at all comparable to these various complex structures is to be found among the unsettled avian population of eastern North America; these birds could ill afford to devote a month to completing their nests, as tropical birds not infrequently do. In Argentina, in the South Temperate Zone, we do indeed find nests of great size and complexity, built by members of the ovenbird family (spine-tails and their relatives) and well described in W. H. Hudson's "Birds of La Plata." But these spine-tails are, I believe, resident where they breed; and Hudson states that some of them devote the winter to erecting, in a leisurely fashion, their impressive castles of sticks.

VI

One difference which certain people profess to find between tropical birds and those of northern lands is that the former are deficient in song. I here denounce, as the grossest and most libelous calumny, statements to this effect which for centuries have appeared in the writings of northern authors. Woodpeckers, kingfishers, hawks and owls do not produce lilting melodies in Canada or in Europe, why should the tropical representatives of these families be expected to do so? These and other groups of birds whose vocal organs are too poorly developed for song—toucans, parrots, motmots, barbets and a host of others—are so much more abundant in tropical than in temperate regions that they are likely to be considered, by superficial observers, as the typically "tropical" birds—whence follows the false conclusion that the bright birds of low latitudes are incapable of song. In justice to these songless groups of birds, it should be borne in mind that

RUFOUS-BREASTED SPINETAIL (*SYNALLAXIS ERYTHROTHORAX*)
ABOUT TO ENTER ITS CASTLE OF STICKS. THE BIRD IS SEEN IN THE RIGHT CENTER OF THE PHOTOGRAPH; THE DOORWAY IS THE ROUND OPENING IN FRONT OF ITS BILL

a number of them, including certain tinamous, trogons, motmots, antbirds and cotingas, utter notes of great, sometimes exquisite, beauty, although their vocal organs lack sufficient range and flexibility for the creation of complex song.

The true song-birds (oscines), although they form a relatively less important constituent among the teeming bird population of tropical lands than in the less varied avifauna of temperate countries, are represented in Central America by a larger number of species than is to be found in the vastly greater area of temperate North America. Thus one of the smaller Central American countries, Costa Rica, with an area of only 18,000 square miles, is the home of forty-three resident species of finches, twenty-two species of wrens, twelve species of thrushes, four kinds of orioles of the genus *Icterus*. One need only come to Central America with senses alert and mind free from prejudice to be convinced that, taken all in all, its birds are at least not inferior as songsters to the northern representatives of the same families.

But it is necessary to time one's visit at the proper season. A few kinds of birds, notable among them the wrens, sing more or less in all months; but the great majority are most tuneful during the breeding season, that quarter of the year occupied by the sun's northward swing from the Equator to the Tropic of Cancer. Some of the finest songsters, including the thrushes of the genus *Turdus*, are songful exclusively during their breeding season. A traveler arriving in Central America in December, at the beginning of the dry season—when the sky is full of sunshine and the meadows and clearings of bright blossoms, when nature is in general in her most attractive mood, but when scarcely any bird sings—might easily conclude that tropical birds are deficient in song. No doubt the prevailing silence of the birds, at certain seasons when earth and air and sky seem most to invite song, has been responsible, no less than the great abundance of species belonging to the songless "lower" families, for the growth of the old error that a parsimonious nature, having richly endowed tropical birds with color, withheld from them the gift of melody. It is as though a stranger, arriving in Costa Rica for the first time now in June, when two months of rain, following a severe dry season, have covered hill and vale with exuberant verdure, but when blossoming is near its lowest ebb, should conclude that this land of a thousand kinds of orchids is deficient in bright flowers!

THE TRAGEDY OF RUDOLF DIESEL

By Dr. HENRY CREW

EMERITUS PROFESSOR OF PHYSICS, NORTHWESTERN UNIVERSITY

ONE of the outstanding biographies of recent times is the story which Eugen Diesel, a contemporary German writer of rare skill, tells of his father, the inventor of the engine. It appeared in Germany last year.

Hundreds of passengers on the Capitol Limited, within the last few years, have enjoyed its complete freedom from smoke and cinders; and many of these travelers have been surprised to learn that the engine furnishing power to the train never stops between Chicago and Washington. The locomotive comes to rest at several points; and the current which actuates the electric motor geared to the driving wheels is, of course, cut off as the train approaches each stopping point; but the "Diesel" maintains its customary speed with a continuity which reminds one of the gentleman in New York who purchased a ticket for Princeton and then stepped aboard a Pennsylvania train. Some forty minutes later, he sat looking out his car window and saw the sign "Princeton Junction" pass by at the rate of 70 miles an hour. Hurriedly calling the porter, he asked "Doesn't this train stop at Princeton Junction?" to which the reply was "No, sah! No, sah! This train does not even hesitate at Princeton Junction."

These non-hesitating "Diesels," as used on the Union Pacific streamliners and on the "400" between Minneapolis and Chicago, are now so familiar to travelers and the personality of the inventor is so little known that it may be worth while here to sketch the essential facts in the life and character of Rudolf Diesel, as set forth in his son's volume, "Diesel, der Mensch, das Werk, das Shicksal" (pp. 491, Hanseatische Verlagsanstalt, 1939). For, in spite of the vast literature which has already appeared dealing with heavy-duty, high-speed, marine and other types of the Diesel motor, little has been written in English about the man himself.

ANCESTRY

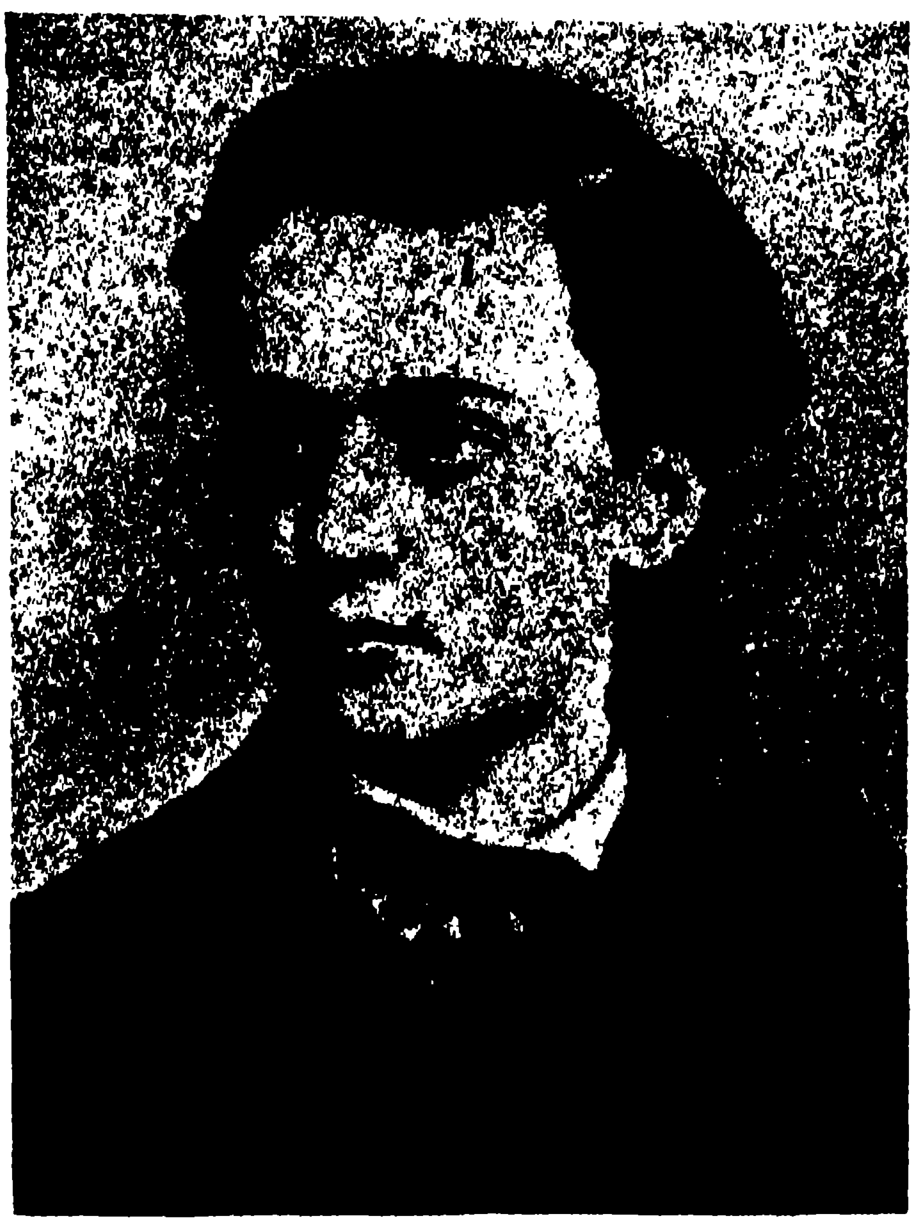
Rudolf Diesel came from a long line of Bavarian Protestants. During the four or five preceding generations, his ancestors were craftsmen and tradesmen, mostly bookbinders, paper-makers and manufacturers of leather goods. They cherished independence and were not afraid of work. In fact, they leave little doubt that the work and character of this remarkable inventor are the result of a long line of well-chosen progenitors and of good home training.

The grandfather, Johann Christoph Diesel—fourth of that name—was born at Memmingen, a town in Bavaria, some 60 miles west of Munich. He later settled in the neighboring city of Augsburg and married in 1828. The father, Gottlieb Theodor Hermann Diesel, was born here in Augsburg on 12 June, 1830. This, it will be observed, was a time when the peaceful quiet of German towns and cities was beginning to be disturbed by the political and social consequences of the French Revolution; also by that significant event known as the industrial revolution in England, with its mechanical and economic consequences. In fact, the continent was already beginning to think in terms of steam-engines, locomotives and power looms. The hand-worker was already finding himself either absorbed or displaced by the machine.

A few years later, during the tempest known as the revolution of '48, Theodor

Diesel, the father of our subject, became tired of his work as a bookbinder in Augsburg and set out on a journeyman's trip which landed him in Paris in 1850. Here he soon found employment in a shop were pocketbooks, purses and other articles were manufactured from Morocco leather.

Now it happened that about the time when Theodor Diesel left Augsburg and settled in Paris a young *Fräulein* of 23 years — Elise Strobel—left Nürnberg and went to London, where she performed the duties of "lady companion" for a certain Miss Wilton; and while there saw the worth-while features of London, became well acquainted with its splendid shops, its art galleries and its crowded streets. Visits to Brighton and other bathing beaches on the English Channel were also on her program. Called back to Nürnberg by the death of her father in June of 1850, *Fräulein* Strobel earned her living by giving lessons in English; but shortly she also migrated to Paris and there gave lessons in both English and German. It was at a little German club —the *Teutonia*—here in the French capital that Theodor Diesel and Elise Strobel first learned to know each other; but it was in London, not in Paris, that the two were married on 10 September, 1855. Curiously enough this excursion across the Channel was caused only by the difficulty—the red tape—of getting from the German authorities the papers which would satisfy the French officials.



RUDOLF DIESEL
AT THE AGE OF TWELVE, 1870.

Boyhood and Education

Their son, Rudolf Diesel, was born, 18 March, 1858, at No. 38 rue Notre Dame de Nazareth, just two streets north of Conservatoire des Arts et Métiers, in Paris. But when he was less than a year old his parents moved a few blocks east to No. 49 rue Fontaine-au-Roi, where he spent most of his boyhood and where much of his time was divided between play and helping make portfolios, traveling cases and other leather goods in his father's *atelier*. Here in constant contact with five or six skilled German hand workers, it would be well-nigh impossible for a boy, during the years from eight to twelve, to avoid an intimate acquaintance with the use of tools or familiarity with the more important properties of matter. To this same boy and his pushcart were entrusted many packages from the father's shop to be delivered to customers in various parts of the city. One can imagine how well such a boy learned to know the streets and many of the historic spots of Paris.

Breadth of learning was added by the fact that at home both German and English were spoken. At the Protestant school, which he and his two sisters attended, as well as on the playground, French was of course the one language heard. In his schoolwork marked ability in drawing was evident. However, in spite of all these opportunities, his boyhood was not a period which Rudolf Diesel looked back upon as a happy one.

From early childhood he was self-conscious and proud, an attitude of mind which was unfortunately cultivated by his fond parents alluding, in the boy's presence, to his cleverness and good looks. Notwithstanding these regrettable limitations, the little fellow thrived in an atmosphere which was then full of such new ideas as the storage battery, the balloon, the gas engine, electric lights, dry-plate photography and various novelties in chemistry. He was a frequent visitor at the nearby Conservatoire des Arts et Métiers, the earliest of all the industrial museums of the world. Here Cugnot's three-wheeled steam wagon, already a century old, could hardly fail to catch his attention; for he was mechanically inclined and mechanically gifted.

Then came the *débâcle* of Sedan, followed by an order issued on 6 September, 1870, that all Germans should at once quit the city of Paris. Two days later the Diesel family had arrived in London, had found a couple of cheap rooms in Herbert Street, just east of City Road, and were already searching for work. The young Rudolf was soon in an English school with occasional visits to the South Kensington Museum. Fortunately for the parents, whose modest belongings were locked up in Paris, an uncle in Augsburg had offered to take Rudolf and look after him until the war was over. Accordingly, the young lad of twelve, with his uncle's address on a card tied about his neck, was put on a train and started *via* Harwich, Rotterdam, Cologne, Frankfort and Würzburg, towards Bavaria, a trip which on account of war conditions occupied eight lonesome days.

Once in Augsburg, however, this sturdy, pious, clear-headed boy was immediately placed in a trade school, where he soon acquired a feeling and a conviction that any future success was dependent upon hard work and a mastery of science. He had indeed already learned that good times have to be arranged for in advance. The sterling qualities of three great nationalities—French, German and English—were already evident in the character and habits of this youth. Each of these three important languages he handled with equal ease. At the age of fourteen he had determined upon the career of an engineer. At fifteen he had passed the final examinations at the *Gewerbe Schule* and had gone to Paris for a visit with his parents—his first glimpse of them during the last three years. From this time forward it was evident that Rudolf could hope for no financial assistance from his father. The income from their shop in Paris was too distressingly small.

His distinctly engineering training began in 1873, when he entered the industrial school with a scholarship for a two-years' course in mathematics, physics, mechanical drawing and modern languages. In the summer of 1875 there was awarded him another scholarship covering his expenses for the next two years at the recently founded *Technische Hochschule* in Munich. Here it was in the home of Professor Bauersfeind that young Diesel met a remarkable fellow student, Oskar von Miller, who proved to be a lifelong friend and adviser, later the distinguished head of the Deutsches Museum.

Curiously enough, one of the chief interests of Diesel at this period was the manufacture of mathematical surfaces of the second order, such as hyperboloids and ellipsoids, by the use of plaster of Paris. His first printed paper (1878) was indeed a description of some of these models which were later exhibited at the Columbian Exposition, at Chicago, in 1893 and won for their author a bronze medal. Precision with demonstrable results was now his "ruling passion strong in death."

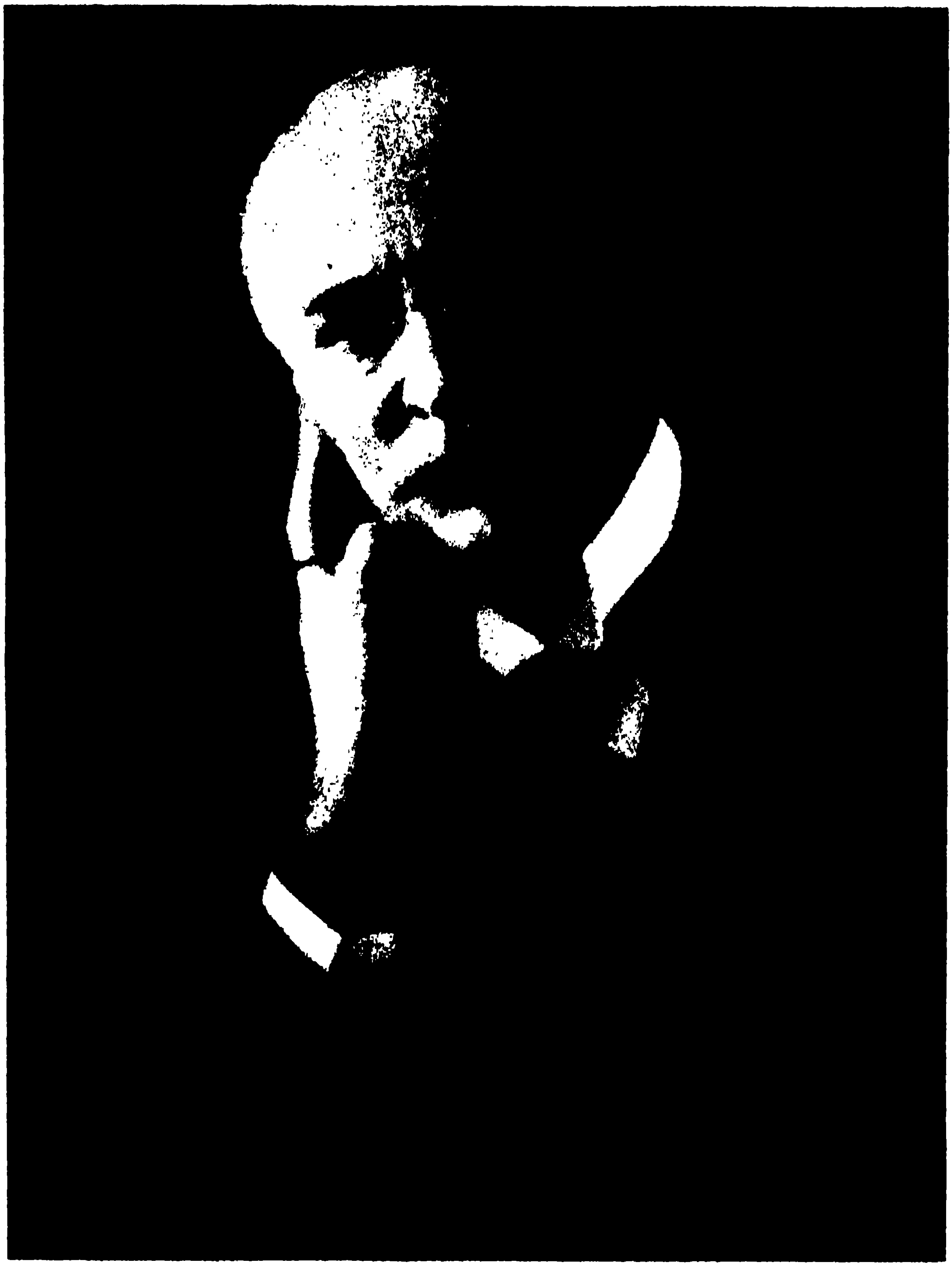
It was in this same year, 1878, while listening to the lectures of Professor

Carl von Linde on heat engines that the twenty-year-old student became deeply impressed by the low efficiency of the steam-engine with its bulky accessories of furnace, boiler and chimney. He was struck also by the radical difference between those machines which merely transmit power, such as a windmill, water wheel or pulley, and those in which power is, so to speak, created, such as the locomotive. Final examinations at the *Technische Hochschule* coming in July of 1879, found Diesel ill at home with typhoid fever. The parents had recently moved from Paris to Munich. Six months later he was given a special examination, which was passed with flying colors.

Professional Training

In the meantime Professor von Linde, recognizing the rare ability of this young man, had arranged with the Sulzer firm in Winterthur—the engine builders who were making his ice machine—to take Diesel on as a volunteer. At the end of this period of preliminary training Diesel was to go to the factory in Paris, where also the Linde machines were being manufactured. This factory was at Quai Grenelle on the Seine in the western part of the city. Arriving in Paris on 20 March, 1880, Diesel was for some time engaged in assembling and in installing the Linde refrigerators; but before many months had passed he was in full charge of the plant and was acting as engineer, manager, inventor, patent expert and purchasing agent. His duties here, as his son points out, in dealing with the extraction of heat from water and with phenomena in the lower part of the temperature scale proved to be excellent preparation for his own later needs in

MR. AND MRS. RUDOLF DIESEL AT THE TIME OF THEIR MARRIAGE IN 1883.



THE MATURE RUDOLF DIESEL.

transforming heat into work in the higher regions of the scale.

Invention and Development of the Motor

September and October of 1881 have significance in the life of our inventor because it was on these two dates, while he was still making ice machines in Paris, that he took out his first two patents. One of these had to do with the making of clear ice; the other was for a process of producing ice directly in a water bottle such as is used on the table, *carafe frappé*. In the manufacture of these devices, he was led to an acquaintance with Heinrich Buz, director of the Maschinenfabrik at Augsburg. Each of these gentlemen quickly learned to appreciate the other; and thus arose a long friendship which later became a determining factor in the life of the clever

but impecunious Diesel. A keener interest in the profession of mechanical engineering now begins to show itself in a memorandum which he deposits with his *alma mater.* Here he indicates various fields such as transportation, milling, brewing and weaving in which there is an increasing demand for men trained in the practical solution of mechanical problems. To the readers of this memorandum, he introduces himself with a certain lightness of touch as follows:

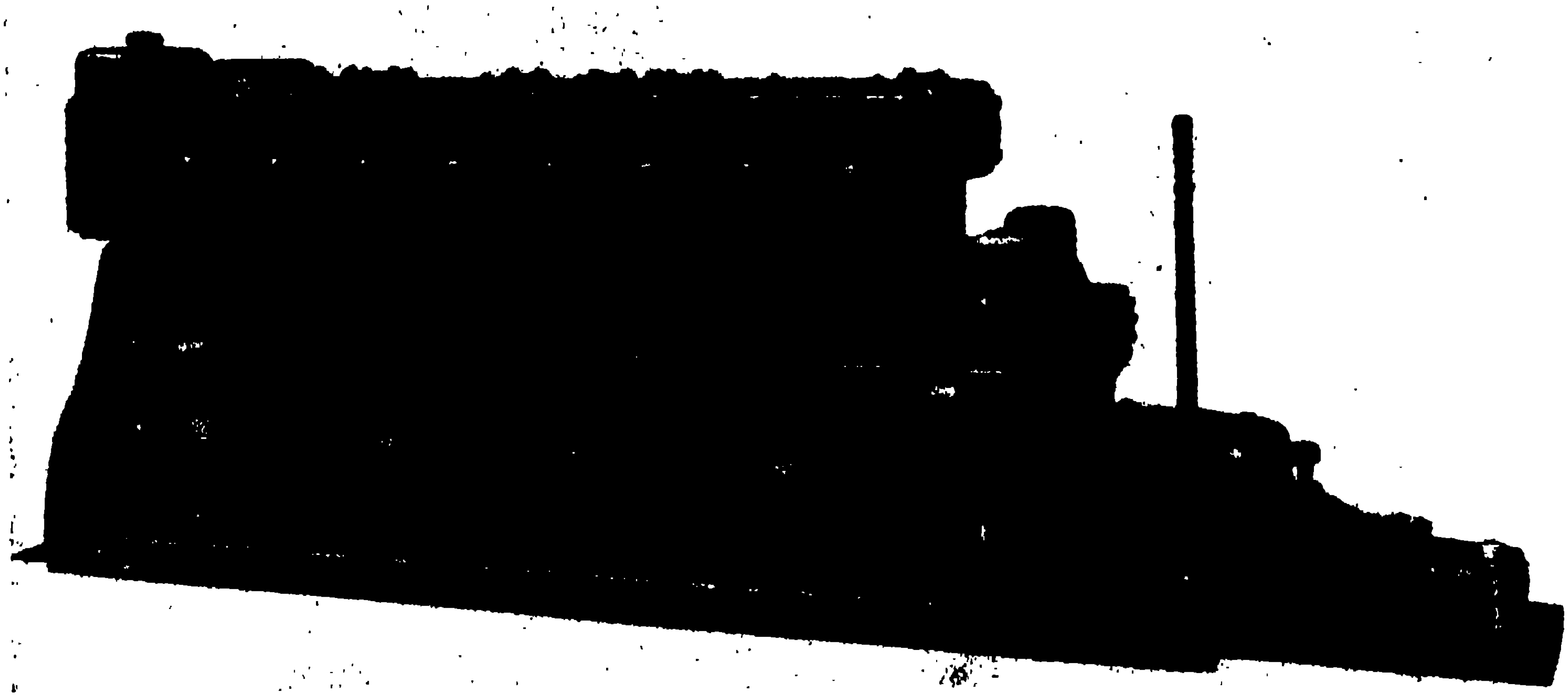
> The undersigned is an ice man, one of the kind who attempts to produce the utmost coolness among men, particularly in the form of ice, ice water, cool air and so forth. This is the type met with especially in our breweries and has recently shown a tendency to expand toward the south. The writer has settled in Paris where he is endeavoring, as a particular aim, to cool the spirit of revenge in the hereditary enemy of Germany.

Things had been going well at the Linde agency on Quai Grenelle in Paris; but Diesel kept thinking of other things. He dreamed of a motor which would operate along the lines of the steam-engine but would use ammonia gas, instead of water vapor, as the working substance. Such an ammonia-motor he had in fact completed in 1889 and thought of exhibiting it at the Paris exposition of that year; but later decided not to do so, mainly because he was just realizing what high temperatures can be produced by compressing a gas. Before the International Congress on Applied Mechanics, which met in Paris on the occasion of this exposition, Diesel gave a lecture on "Refrigerating Machinery and its Field of Application." So perfect was his spoken French that many in the audience took him to be a native Frenchman; and so he was as regards birth, though not as regards citizenship. 'Twas about this time that the gaudy funeral of Victor Hugo (31 May, 1885) took place and that General Boulanger was stirring up hatred against Germany. Such a chauvinistic spirit had a depressing effect upon the sales of refrigerating plants and cold storage devices which had been invented by a German professor and were being manufactured in the German part of Switzerland. Linde also was concerned about the diminishing sales of his inventions in France, and, knowing that Diesel would be glad to leave Paris, he proposed that the young man return to Germany, take up residence in Berlin and manage the business in the northern and eastern part of this country. The salary arrangements—30,000 francs—were satisfactory. Diesel, however, pointed out that he would like to develop and perfect some ideas of his own regarding a new engine. To this suggestion the elder engineer was not very hospitable. Such an attitude of mind on the part of a productive scholar surprised Diesel and made him hesitate; but the opportunity to return to Germany overbalanced all objections and the offer was accepted.

Marriage

Let us now go back half a dozen years in order to pick up another thread. There lived at that time in Paris a prosperous German merchant whose wife was "at home" to her friends every Thursday afternoon. At one of these teas, Diesel and his friend Oskar von Miller happened to meet an attractive and alert young *Fräulein,* Martha Flasche, who had a fluent command of both English and French, and was employed as a tutor in the family of this merchant. To make a short story still shorter, she accepted Diesel's proposal and in the following year they were married at Munich on 24 November, 1883. Another year later their first child was born. Then came a daughter on 15 October, 1885. The third and last child, Eugen, the biographer, whose story I am here briefly sketching, also made his first appearance in Paris. This was on 3 May, 1889.

Curiously enough, Diesel had never been in Berlin until he went there as engineer for the Linde interest in 1890.



AN EIGHT-CYLINDER MARINE DIESEL ENGINE
READY TO BE GEARED TO THE PROPELLER SHAFT OF THE VESSEL. (FAIRBANKS-MORSE.)

The pride of his youth had not yet abated. Accordingly the family was located in a rather pretentious apartment at 113 Kurfürsten Damm, a residential district then on the western edge of the city. A little later they moved into more modest quarters on the north side of the *Thiergarten.* Here in the Prussian capital five years were spent before making their next and final move to Bavaria in 1895.

Berlin Residence

Diesel was immensely pleased with the push and drive which were evident here in the imperial capital, and also with the absence of any political or governmental interference with business. Very shortly he found himself elected to the board of directors of the Market House and Cold Storage Company. Among his many friends—industrialists, army officers and others—he mentions Professor Slaby, who used to say that the two inventors who had made an indelible impression upon him were Diesel and Lilienthal.

By March of 1892 Diesel had given much time, thought and money to improvements upon the internal combustion engine invented by Dr. Otto in 1876. His first patent along this line was granted on 28 February, 1892; and, in order to push these ideas of high compression and elimination of the ignition-spark, Diesel published in January of 1893 a book entitled *"Theorie und Konstruktion eines rationellen Wärmemotors zum Ersatz dem Dampfmaschinen und der heute bekannten Verbrennungsmotoren."*

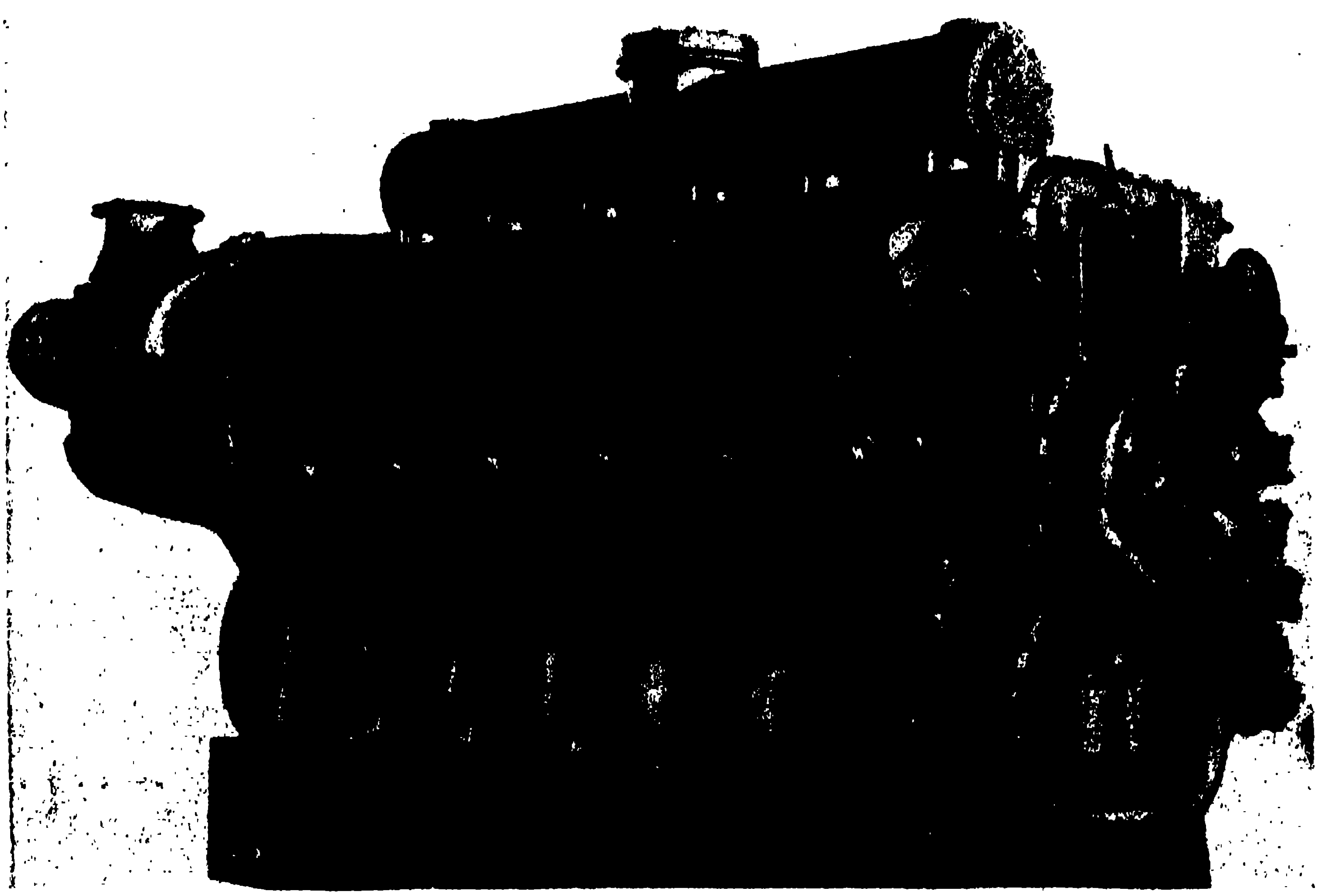
Within a month after the appearance of this volume he had arranged with the Buz factory at Augsburg for the construction of an experimental engine along the novel lines laid down in his patent specifications. A second patent was obtained in 1893 and was soon ceded to the Krupps of Essen, who had already agreed with the Buz firm to help develop the new engine. Diesel was to receive 3,000 marks a year to oversee the work and suggest improvements. A month or so later, 16 May, 1893, the Sulzer company of Winterthur in Switzerland

joined the combination, thus making three important firms who had expressed their interest in the future of the Diesel motor. It was at this time that he closed up his business with the Linde Ice Machine Company and moved to Augsburg where, in the Buz works, an experimental laboratory was built and the assembly of the first motor began. A couple of years later the family moved from Berlin to Augsburg and thence almost immediately to Munich; and here he spent the remainder of his life, except for numerous long business trips to foreign countries, often with his wife as traveling companion.

Development of the Motor

The first experimental machine was ready for trial on 10 August, 1893. It was brought up to speed by an independent source of power. At the instant, however, when fuel was introduced into the cylinder by the feed-pump, a violent explosion occurred. Diesel was immensely pleased with this because he had learned from it that the cylinder walls must be made stronger and—what was more fundamental—that the heat of compression was really sufficient to ignite the fuel. It must not be forgotten that, at this early period, the proper size and shape of the cylinder were unknown, the right amount of clearance between the top of the piston and the end of the cylinder was unknown, and the factory at Augsburg was trying to discover those essential facts which now—a generation after Diesel—are well known, if not to every intelligent boy, at least to thousands of mechanical engineers and skilled workmen all over Europe and America.

A little later this 13-horsepower engine was licked into shape and Diesel became so hopeful, in his characteristic way, that he went to Paris and Ghent in April, 1894, and awakened considerable



A TWELVE-CYLINDER GENERAL MOTORS DIESEL ENGINE
REQUIRING ONLY A GENERATOR AND AN ELECTRIC MOTOR BUILT UPON A CHASSIS WITH DRIVING WHEELS TO MAKE A COMPLETE POWER PLANT FOR A LOCOMOTIVE.

enthusiasm—more indeed than was warranted by later events—over the new invention. For six months more of experimentation showed that the problem was not yet solved; but Diesel, feeling that he had learned much, was undiscouraged. Buz proposed to build an entirely new engine avoiding all the faults of the present one; but it was finally decided to retain the original 13-HP machine and to try gas as a fuel. On 12 October, 1894, the first satisfactory indicator diagram was obtained. The Krupps now sent four men to see the machine in operation. By 28 January, 1897, a second engine had been completed and given a trial which established its success with gasoline as fuel. After five years of continuous and laborious experiment a new engine had been produced which was working smoothly and was showing greater thermal efficiency than any other engine in existence. Interest was expressed by the ablest engine builders of France, England, Belgium and Germany. Yet Diesel was not forgetting that his original problem of using crude oil—and even powdered coal—was still unsolved. He knew also something about the vulnerability of patents, and he knew only too well that the value of a patent depends largely upon the strong will, brains and ability to win friends which lie back of it. In spite of these conditions, his

General Motors Corporation.

A MODERN STREAMLINED PASSENGER TRAIN

HAULED BY A DIESEL LOCOMOTIVE. THIS ENGINE WITH ITS HIGH THERMAL EFFICIENCY, CLEVER DESIGN AND ACCURATE WORKMANSHIP, IS THE ONE EMPLOYED IN THE "CITY OF SAN FRANCISCO," THE "400," THE "BURLINGTON ZEPHYR," THE "CAPITOL LIMITED" AND OUR OTHER BEST TRAINS.

son and biographer considers the spring of 1897 as the climax of his father's career. For the Augsburg company and the Krupps now felt so much confidence in the patents that they guaranteed Diesel 50,000 marks annually for his royalties. A few weeks later a Scotch firm (the Mirrlees Watson Yaryan Co.) after a conference between Diesel and Lord Kelvin, agreed to pay him 20,000 marks annually for his patent rights. A yearly income of 70,000 marks was not only a new experience for the impecunious inventor, it was evidence that in the opinion of these leading firms the "infantile diseases of the new invention" (*Kinderkrankheiten neuer technischer Schöpfungen*) had been successfully passed. It was in September of 1897, at Baden-Baden, that Adolph Busch, of St. Louis, first met Diesel. A contract for the manufacture of the engine in America was signed almost immediately; and the Busch-Sulzer Company of St. Louis is to-day to be reckoned among the important manufacturers of this product.

On 17 September, 1898, a new German Diesel Motor Company was formed, not a manufacturing concern, but merely a combination which held the patents. It was, in fact, a holding company which paid Diesel 1,250,000 marks in cash besides giving him a large number of shares of stock. The forty-year-old inventor naturally considered himself a wealthy man: and the family moved into a commodious and handsome apartment in Munich. Elaborate offices were set up in the adjoining apartment. A little later a large and expensive house was built. Enormous investments in oil-fields and other pieces of real estate were made. And all this was done in apparent forgetfulness of the fact that his patents were now owned by the General Diesel Motors and were therefore entirely out of his hands. He forgot also that the interval which engineers call "the period of development" is generally a long one—often ten to thirty years. His familiarity with motors far exceeded his financial judgment and his knowledge of the stock market.

The press of business which he now encountered made serious inroads upon his health, which he tried to repair by the use of *antipyrin* and bromides. The buoyancy and over-confidence of this generous soul were evident in nearly everything he did. It was not long, however, before the real estate declined in value, the oil-wells ceased to pay and the cost of maintaining the large residence could not be met. The Augsburg factory in which he was a large shareholder dissolved in 1911. Further inroads were made upon his peace of mind by lawsuits. Yet withal the evidence is that Diesel was essentially modest, always carried a fine spirit, always kept his troubles to himself; qualities which call for courage.

We return now to the story of the motors. These were first publicly exhibited in 1898 at the Mechanical Exposition which was held in Munich on the site of the present Deutsches Museum. Of the four engines there shown, one was made by the Krupps, one by the factory at Augsburg, one at Nürnberg; and the fourth, built by the Sulzer Motor Company, was employed to drive the liquid-air machine devised by Diesel's teacher, Carl von Linde of Munich.

This combination of a heat engine with a refrigerator to produce the exceedingly low temperatures of liquid oxygen and nitrogen is cited by the biographer as an impressive illustration of the fact that, in the modern theory of physics, heat and cold belong to one and the same category.

Among the outstanding scientific novelties at the Paris Exposition of 1900 was a group of five Diesel motors, four of them built in France, the other one at Augsburg. It was here, on the turn of

the century, that Diesel first had the pleasure of meeting Count Zeppelin at the launching and trial trip of "Zeppelin, I" in June of 1900. The realization, however, of Diesel's hope that a dirigible should be driven by one of his engines, was delayed for 35 years and hence to a time long after his death. Another group of Diesels was shown at the St. Louis Exposition in 1904; and one of them, indeed, is in use to-day (1940) at Key West in Florida. The General Motors Corporation at the Century of Progress Exposition in 1933 derived the power for their assembly line from a set of powerful Diesel motors which attracted a steady stream of visitors and adumbrated the great factory of the Electromotive Corporation at La Grange, Illinois, where no less than 3,000 men are to-day engaged in equipping streamlined trains—both passenger and freight—with Diesel locomotives. The era of the small Diesel motor began about the time of the Brussels Exposition in 1910. A four-cylinder engine of this period was applied to an automobile and is now preserved in the Deutsches Museum. But hundreds of them, far from being museum specimens, are now driving long-distance trucks in America.

A new chapter in the history of these motors opened in 1912, when the *Selandia,* a large ocean-going vessel built in Copenhagen, completed her first long voyage to and from Bangkok, the capital of Siam. For this achievement suggests that the introduction of the Diesel marine engine—now proceeding rapidly—is possibly the greatest improvement in ocean navigation since the substitution of steam for wind propulsion. Amundsen had already employed this same type of motor in Nansen's ship, the *Fram,* on his trip to Antarctica in 1910. Thirty years later Dr. Thomas C. Poulter used two Diesel engines in his *Snow Cruiser* in these same polar regions. The rapidity with which the marine Diesel has been adopted is not a matter for surprise, since the latest steam turbines give an efficiency of only 29 per cent., while a good Diesel yields as high as 37 per cent. Shortly before his death Diesel addressed a meeting of English shipbuilders and, at the dinner which followed, was seated at table beside Sir Charles Parsons, the pair thus representing a good-natured rivalry between the two heat engines, the steam turbine and the Diesel motor.

Visits to America

His first trip to the United States was a hasty one made in 1904 on the occasion of the Louisiana Purchase Exposition at St. Louis. On his second voyage, in March of 1912, he was accompanied by Mrs. Diesel. They visited Cornell University, the Naval Academy at Annapolis, St. Louis, and other places of scientific and academic interest. The 6th of May found them at Orange, N. J., for a visit with the Edisons, who shared with the Diesels the friendship of Oskar von Miller. The simplicity, the directness, the energy and the abstemious habits of Mr. Edison made a deep impression. His playful parting message, as they left his home, was "Don't eat too much!"

The Catastrophe

The last few years of Diesel's life were filled with intense labor. He was constantly making new plans, lecturing and traveling. Financial troubles increased when he entered the speculative field, where costly mistakes were made because he was totally unacquainted with the weapons there used. Teeming with energy and pride, exceedingly sensitive in mind and heart, he was capable of great suffering, and he did suffer intensely.

The spring of 1913 found the Diesels—husband and wife—in Sicily, where, under Italian skies, they deeply enjoyed visiting historical spots. The only cloud in the sky was the publication at this time of Lüders' book minimizing—not to say slandering—Diesel and his achievements—an unwarranted and painful attack.

It was in June, 1913, that the Diesels gave a reception in their big Munich house to several hundred American engineers; and were invited to visit the San Francisco Exposition of 1915, with transportation through the Panama Canal on the *Fram*.

In September of 1913 appeared his book *"Die Entstehung des Diesel Motors,"* the outcome of a lecture he had given in the preceding autumn before a group of naval architects. In the concluding pages of this volume the author has given us some of his philosophy of life. His sentences, though not quite so brief, remind one of the maxims from *Poor Richard's Almanac.* Space permits only two or three extracts.

An invention consists of two parts: the idea and its execution.

An invention is never a purely intellectual product, but is the result of a battle between the idea and the material world.

The birth of an idea is the happy moment in appears possible and reality has not yet entered appears possible and realtiy has not yet entered into the problem.

The inventor must be an optimist since the full driving power of an idea is to be found only in the mind of the originator. He alone has the sacred fire to push it through.

Visits with his younger son to the old familiar places in the Bavarian Alps and calls upon long-time friends had occupied much of the summer of 1913. He set his Munich house in order and accepted the invitation of George Carels, a fellow engineer of Belgium, to come *via* Ghent and join him on a trip to London for a conference meeting there on the 30th of September. It was planned also to attend the inauguration of a Diesel factory at Ipswich. On the 26th of September he went with his younger son to Frankfort, where his wife and daughter had preceded him. After a delightful visit of two days, including an excursion to the neighboring hills, the son accompanied the father to the railway station, where a first-class ticket—unusual for Diesel—to Ghent was purchased. The father bade the boy an affectionate farewell, and was thus seen for the last time by any member of his family. On the 29th of September, writing from Ghent, he sends loving messages to his wife and to each of the children.

His traveling companions, Messrs. Carels and Luckmann, report that they had dinner with Diesel on board the steamer *Dresden* after embarking at Antwerp. Dinner over, they enjoyed a stroll up and down the deck; then each to his stateroom. These two friends, not finding Diesel on deck as the steamer was arriving in Harwich, went to his room, but their knock was not answered; so they opened the door, only to find that the bed had not been slept in. A thorough search of the vessel proved that he was not aboard. The family was notified. No trace of the body was ever found.

The contents of his safe at Munich showed that his property had dwindled during recent years to practically nothing. The price of Diesel stock in the English company fell at once from 12 shillings to 5; and then to 2 shillings. "It is difficult to imagine," said an English friend shortly after his death, "anything more delightful than his private life. Well balanced, he appeared to combine the thoroughness of the Germans with the culture of the French. He possessed that modest self-control which one finds in a high-class American. There was in him no trace of snobbishness or mediocrity."

We shall probably never know which alternative to accept: self-destruction or the enmity of some jealous rival. We are certain only that his generous heart found peace at the bottom of the English Channel, where to-day that heartbreaking folly called war is sending so many brave souls to keep him company. We grieve that he never lived to see his ideas come to full fruit.

PHYSICAL EFFECTS OF EXTREME PRESSURES

By Dr. ROY W. GORANSON

GEOPHYSICAL LABORATORY, CARNEGIE INSTITUTION OF WASHINGTON

It is well known that many of the physical properties of a substance can be materially changed by applying external pressure to the system. Even so, the question may still be asked: What kind of valuable information may be expected from further high pressure investigations and what usefulness may such investigations have? This question can not be answered by merely reviewing specific examples of pressure effects, but requires a correlation of our present knowledge and an exploration, by means of theoretical considerations, of the still unknown regions of pressure phenomena.

General Relations

Temperature and pressure both rise with increasing depth in the earth, attaining values of the order of 3,000° C. and 3,500,000 bars at the center (1 bar $= 10^6$ dynes/cm$^2 = 0.987$ atmospheres $=$ 14.5 lbs/in^2). The behavior of matter at very high pressures is thus one of the outstanding problems of both geophysics and physics.

The program initiated by the Geophysical Laboratory of the Carnegie Institution of Washington, organized in 1908 for a study of the physical properties of the earth and its constituents, therefore included as fundamental both high temperature and high pressure investigations. At about the same time a program of high pressure research was also begun at Harvard University by P. W. Bridgman.

Pressure and temperature may be correlated by means of thermodynamics. From these relations it is seen that pressure acts in an opposite manner to temperature and thus opens up a field that can not be deeply surveyed from the temperature axis alone. If a solid is heated it expands, eventually melts and finally evaporates; if now this vapor is compressed it retraces these steps provided it is below its liquid critical temperature, *i.e.*, the temperature above which the liquid state can no longer exist. With further increase in pressure, however, this solid may break down again and again into other crystalline forms which are stable only at high pressures and are successively closer packed (denser) and more symmetrical (tending toward isotropicity) in configuration. A classic example of such a system is water, for which Bridgman has found six different pressure forms of ice. If we move out into the pressure field along the $-40°$ isotherm we find successively ice I stable to 2,080 bars; ice II, stable from 2,080 to 4,490 bars (ice III is a higher temperature modification of ice II for the pressure region from 2,130 to 3,440 bars and ice IV is non-existent); ice V, stable from 4,490 to 6,225 bars; ice VI, stable from 6,225 to 20,600 bars; and ice VII, stable above 20,600 bars. Ice VII at 50,000 bars is more than twice as dense as ice I at atmospheric pressure. It is also interesting to note here that, unless the pressure-melting curve of ice VII has an improbable maximum or asymptotically approaches some value lying below 374° C., the liquid state must cease to exist at pressures in the neighborhood of 75,000 to 100,000 bars.

The mutually antagonistic effects of temperature and pressure are best studied by consideration of the free energy

(thermodynamic potential) relations. In ordinary mechanics the equilibrium state of a system is specified by the minimum of its potential energy (energy of position). Where thermal changes must be treated it is necessary to extend this concept by use of the Second Law of Thermodynamics. The relation so obtained has been called the "maximum work," "free energy" or "psi" function, and with it we are able to probe homogeneous stability relations. For example, the "psi" of a compressed gas is equivalent to the maximum work it could do on release of the external pressure at constant temperature. In the still more general problem which takes into account heterogeneous, or phase, equilibria, *i.e.*, of such systems as solid–liquid, liquid–gas, or solid A–solid B, a further extension is required. The expression deduced has been called the "free energy," "thermodynamic potential" or "zeta" function. Here, too, the equilibrium condition is that of minimum free energy. Thus a metastable system is one containing excess free energy which is released on transition to a more stable phase. Many of these unstable modifications persist for considerable periods of time and such examples are all about us. An extreme case is the unstable uranium atom. Fission of one pound of these atoms would release the equivalent of the energy obtained by burning 3,000 tons of coal. Temperature metastability is exemplified by quenched or frozen systems—the best known is window glass. A striking example of pressure metastability is diamond, which is discussed later.

A reaction that is promoted by increase in pressure is inhibited by increase in temperature, as is evident from Figs. 2 and 3, discussed later. The initial ratio of the two effects differs from system to system, but, as a rough order of magnitude, a pressure of several hundred bars is required to compensate for a ten-degree rise in temperature.

Theoretical Developments

In the last thirty years considerable data have been accumulated to pressures of a few ten-thousand bars, but only recently has any serious attempt been made to extend the range of pressure materially. Recent developments in the field of theoretical physics have, however, been very provocative in that vistas have been opened up concerning the properties of matter at very high pressures. From such studies it may be deduced that at sufficiently high pressures all matter tends to behave in a uniform manner. Pressure-volume relations applicable at very high pressures have been computed by H. Jensen[1] from a modification of the hypothetical Thomas-Fermi atom model. These relations are initially functions of the atomic nuclei but approach asymptotically the pressure-volume curve of a homogeneous electron gas model at extremely high pressures. The curve for the element of atomic number 26, which is iron, is illustrated in Fig. 1. Distinctions, as we know them, between solids, liquids and gases must finally vanish. Extrapolation of the experimental curve for iron to the theoretical curve shows that these relations become valid for metals only at pressures exceeding those found at the center of the earth.

Again, certain metals of the transition series of elements—for example, iron, cobalt and nickel of the first transition series and gadolinium of the third, or rare earth, series—together with certain compounds of these elements possess a relatively rare physical property known as ferromagnetism. These substances are made up of a great many regions or domains in each of which the magnetic moments of the atoms are parallel. If these domains are large enough to enclose a considerable number of atoms (of the order of 10^{14}) they can be reoriented into any desired direction by suitable

[1] H. Jensen, *Zeit. f. Physik*, 111: 373–385, 1938.

external magnetic fields. When the energy of motion, obtained from increase in temperature, becomes sufficient to exceed the "interaction forces" by which a domain is bonded together, then the substance loses its ferromagnetism and this temperature is known as the Curie Point.

From some other concepts it is inferred that, although in certain instances the Curie Point may be raised initially by pressure, ultimately at sufficiently high pressures this property of ferromagnet-

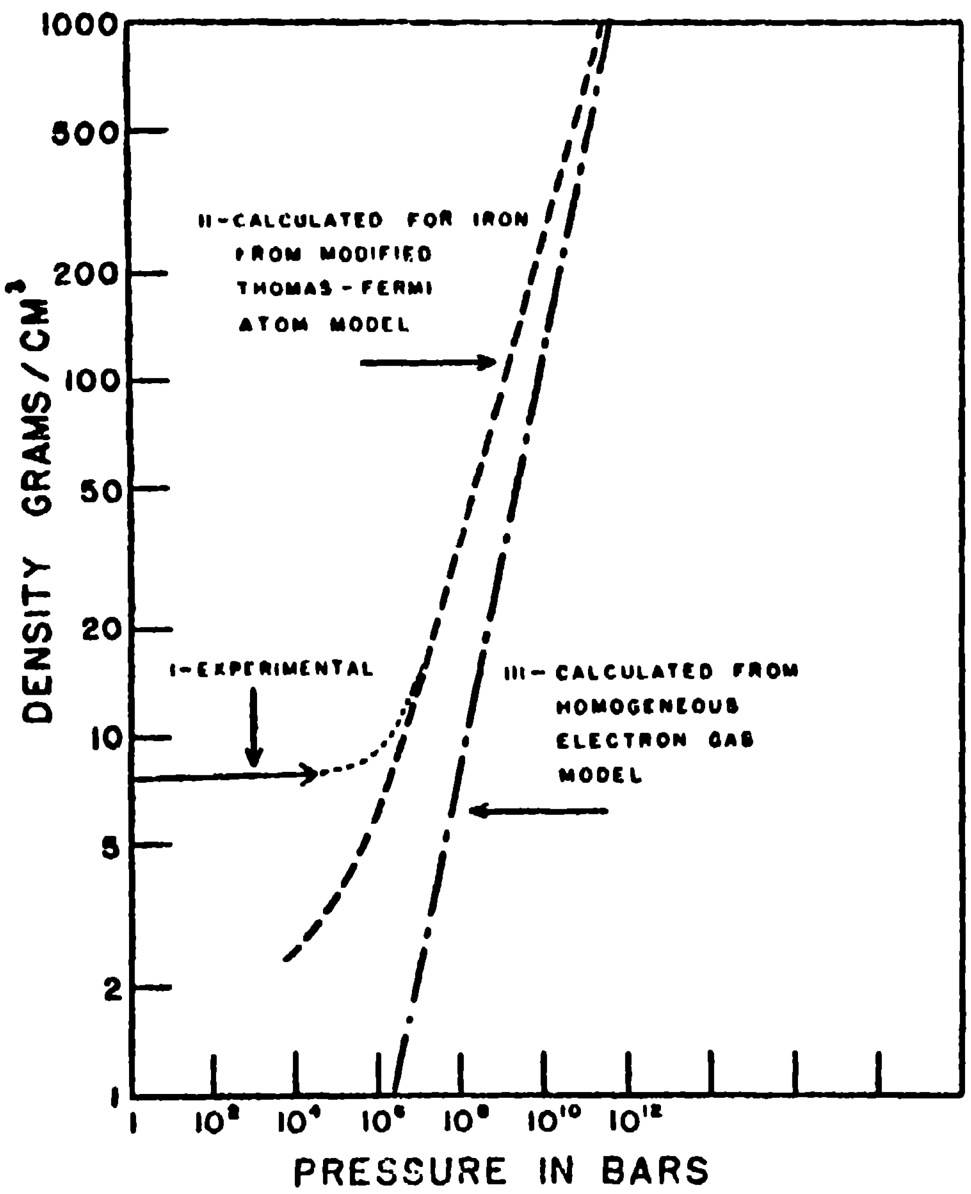


FIG. 1. PRESSURE-DENSITY RELATIONS. CURVE I GIVES THE EXPERIMENTAL VALUES FOR IRON. CURVES II AND III WERE COMPUTED BY H. JENSEN. ATTENTION IS CALLED TO THE GAP BETWEEN CURVES I AND II, INDICATED IN THE DIAGRAM BY THE DOTTED PORTION, WHICH LIES BETWEEN 12,000 AND 10,000,000 BARS PRESSURE.

ism will cease to exist at any temperature. The basis of such a prediction is somewhat related to a familiar principle, namely, that two bodies can not occupy the same space at the same time, except that for this argument one must deal with an n-dimensional phase space. From the present-day accepted theory of atomic structure the electron of an atom system may be specified by certain quantum numbers of which electron spin is one of the coordinates. Assume now that we have two such systems each with an electron of similar phase coordinates, including parallel spins which thereby impart a net magnetic moment to this ensemble. If these two systems are now squeezed closer and closer together their phase space fields will begin to overlap and at some critical distance of approach they must separate by moving to different parts of this phase space. This movement occurs along the spin dimension because it is the path of least resistance. The electrons thereupon switch to antiparallel spins and the ensemble loses its magnetic moment. The external pressure needed to squeeze the systems to this stage is estimated to lie in the neighborhood of a million bars.

It should be noted here that these effects of temperature and of pressure on ferromagnetism are very different; temperature breaks up the alignment of the magnetic moments in the domains, whereas pressure destroys the source of these moments.

The intermediate pressure region lying between ten thousand and a million bars is still somewhat of a wilderness requiring the cooperation of experimental and theoretical physics for its exploration. Experimental work on the elastic, electric, magnetic and other physical properties of matter at very high pressures, such as changes in crystalline state and chemical composition, is very much to be desired. Plausible theories that may be replaced by many other equally probable hypothetical pictures can not be considered as having satisfactorily explained anything, and this is the state of affairs concerning our knowledge of the interior of the earth, its constitution, composition and magnetic properties.

Pressure Transformations

It is only recently that a choice could

be made of the many suggested explanations for deep focus earthquakes, *i.e.*, those initiated at depths of about 700 kilometers. By a process of elimination it can be shown that they are probably the result of a temperature–pressure–phase change mechanism.

This mechanism is operable if the material at a depth of 700 kilometers can exist as either of two forms A or B, B being denser, and the temperature is such that fluctuations in the thermal gradient may effect the transformation from one form to the other. Lowered isotherms then induce the change A → B with accompanying collapse, and raised isotherms the change B → A with expansion. From a study of the earth's past history we learn that large temperature changes must have occurred. Moreover, certain periodicities may also be adduced, and if these are used in conjunction with the above mechanism we have in addition a plausible explanation of crustal uplift and downwarping.

Pressure–phase transitions are as a rule reversible, *i.e.*, the change from B to A with falling pressure occurs as readily as that from A to B with rising pressure. A large number of these reactions, however, are very sluggish at low temperatures. Thermodynamically the efficiency of a pressure reaction, *i.e.*, the completeness of conversion, increases with decreasing temperature. Practically this is not the case and, in order to obtain a reasonable or finite rate of reaction, special procedures must be used. One of these is to supply the system with excess energy, called activation energy, accomplished by superpressing the substance far above the equilibrium pressure or by working at higher temperatures. Another method is to reach the desired state *via* a series of intermediate processes, as by introduction of a catalyst to induce surface chain reactions or by crystallization from solution. Efficiency in conversion must in practice be sacrificed for higher rates of production.

The following may be a suggestive, even though imperfect, analogy: The lowest potential energy level, and therefore most stable position, of a boulder resting on a saucer-like depression on the slope of a hill is on the valley floor below. In order to reach this lower level work must be done on the boulder in order to push it up over the edge of the depression, which constitutes an energy barrier. If now the region is subjected to a series of earthquakes the boulder will begin to oscillate in the saucer. Finally one of its oscillations may bring it up and over the lip of the saucer, whereupon it starts down and, by acquiring sufficient momentum, hurdles other saucer-like depressions farther down the slope until it reaches the bottom. This would constitute the "activation energy" method of initiating movement. Transfer by the "catalytic" method would be accomplished by replacing the saucer with a series of saucers having correspondingly shallower depressions. Oscillations too small to carry the rock over the lip of the single saucer can start it along this train and, after hurdling the first one, it gains sufficient momentum to carry it through the others. A variant of the "activation" type of process, used in atomic physics, is bombardment by a projectile of sufficient mass and velocity to knock it out of the saucer.

It is possible to quench, *i.e.*, freeze, the high pressure modification of such sluggish systems and take it down to atmospheric pressure for examination. One of these substances is carbon, which exists in two crystalline forms, graphite and diamond. It has stirred the imagination of many aspiring diamond synthesizers and, to answer the many requests for information, a temperature–pressure phase diagram was computed for the graphite–diamond reaction, of which Fig. 2 is an up-to-date version. Graphite exists stably in the temperature–pressure region lying to the left of the curve, and diamond exists stably in

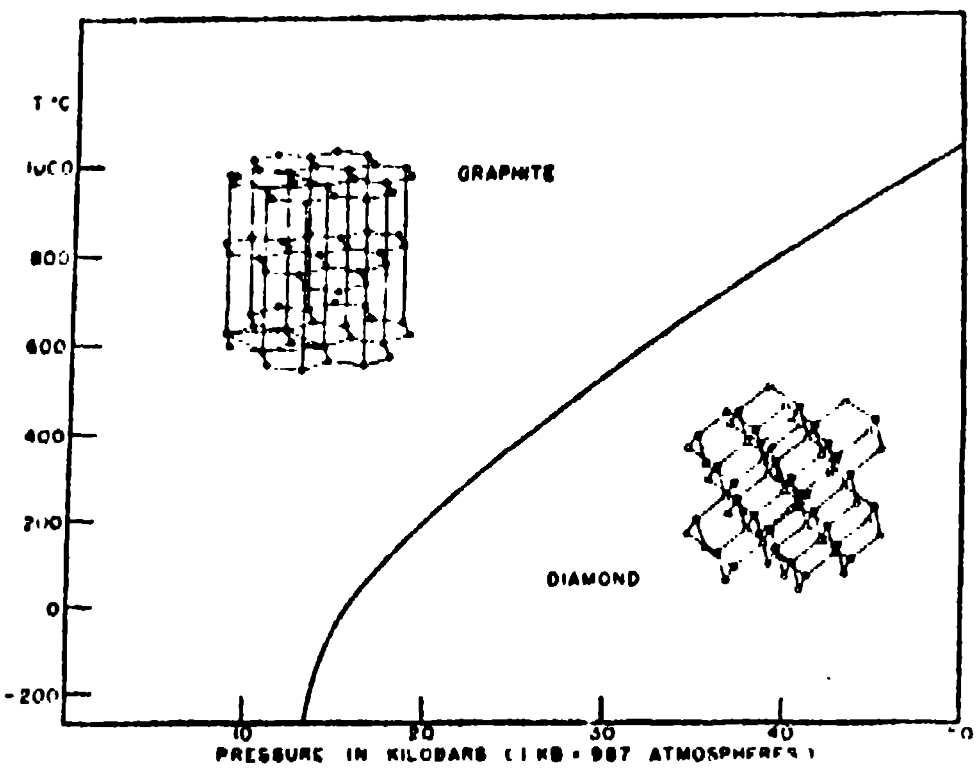


FIG. 2. THE STRUCTURAL MODELS OF GRAPHITE AND DIAMOND DESIGNATE THEIR RESPECTIVE STABLE REGIONS FOR DIFFERENT CONDITIONS OF TEMPERATURE AND PRESSURE. THE CURVE REPRESENTS THE BOUNDARY SEPARATING THESE FIELDS.

the region to the right of the curve. The latter is therefore unstable at pressures below 13,000–14,000 bars and, but for the high energy barrier between it and graphite at low temperatures, it could not exist at the surface of the earth.

The space-lattice crystal structures illustrated in Fig. 2 show very clearly the striking differences in the physical properties of these two substances. The circles represent the centers of carbon atoms, and the reciprocal of their separation is a function of the strength of the bonds holding them together. The planes of easiest cleavage are thus those across which the separation is greatest. In this connection it is interesting to note that the diamond lattice may be obtained from the graphite lattice by means of an axial compression and rotation.

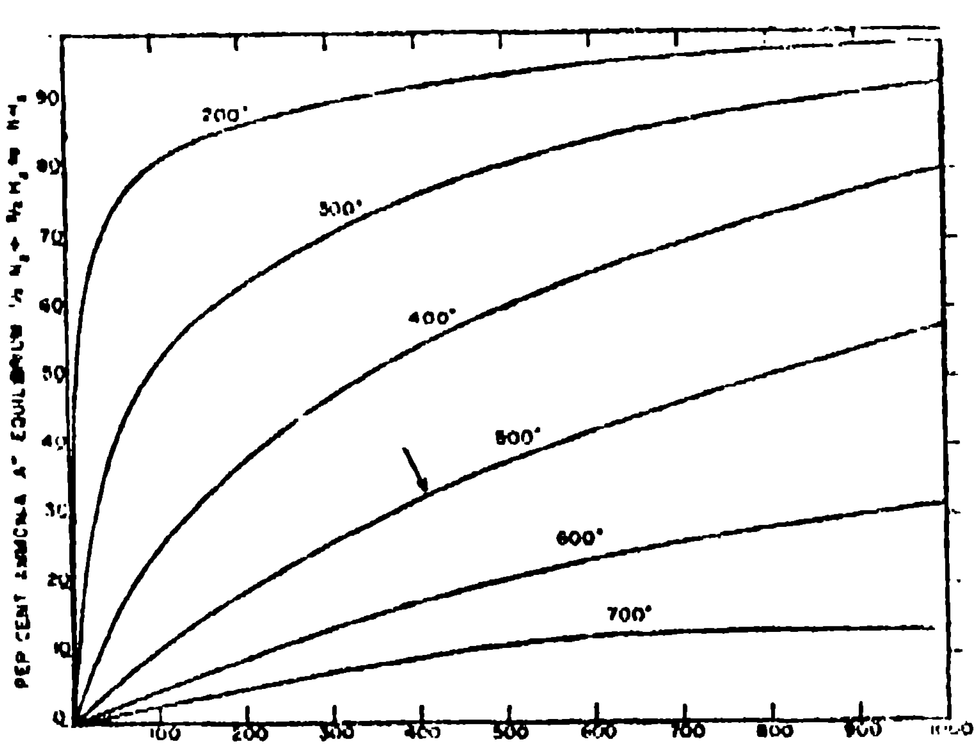


FIG. 3. PERCENTAGE OF CONVERSION OF NITROGEN AND HYDROGEN TO AMMONIA FOR DIFFERENT TEMPERATURES AND PRESSURES. IT INCREASES THEORETICALLY WITH INCREASING PRESSURE AND DECREASING TEMPERATURE.

Practical Uses

The more important practical utilizations of pressure are those concerned with changes in chemical constitution and known as pressure–phase or heterogeneous equilibria. Pressure synthesis may perhaps justly be said to have originated with work on the amine dyes, but its real impetus began about 1910 with the Haber–Bosch process for fixation of nitrogen from nitrogen and hydrogen to form ammonia. Equilibrium curves for the reactants nitrogen, hydrogen and ammonia have been plotted in Fig. 3 from data of the Fertilizer Research Division of the Bureau of Plant Industry, U. S. Department of Agriculture.[2] For example, at 500° C. and 410 atmospheres, indicated in the diagram by an arrow, ammonia constitutes a third of the mixture. It will be noted also that the yield should increase with increasing pressure and decreasing temperature, but in practice catalysts and temperatures of 400 to 600° C. are used to push the reaction along.

The synthesis of methanol and ethanol, and the hydrogenation of coal, oil and other carbonaceous matter are typical examples of similar processes. Active research is also being prosecuted on the synthesis of higher alcohols. Another type is exemplified by the cracking of oils and fats under pressure.

Other applications of higher pressures might be made in such varied fields as (*a*) polymerization processes, which are very important to the plastics indus-

[2] Fertilizer Research Division of Bureau of Plant Industry: A. T. Larson, *Jour. Am. Chem. Soc.*, 46: 367–372, 1924.

try; (*b*) pasteurization and sterilization by hydrostatic pressure in cases where high temperature is destructive to the compounds; (*c*) increased rates of production for certain reactions; for example, the research department of the Imperial Chemical Industries (British)[3] has found that the rates of certain "slow" reactions in the liquid phase, such as that between pyridine and ethyl iodide in acetone, are accelerated about ten times at 3,000 bars, fifty times at 8,000 bars, and perhaps several thousand times at 20,000 bars pressure; (*d*) purification and concentration of materials. Solubility and melting point relations are changed by pressure, and these rates of change in general vary for different substances. Separations by fractional crystallization (freezing) which are difficult or impossible at atmospheric pressure may be readily made at higher pressures under certain conditions. These conditions can be predicted from heat and volume changes on freezing of the various components of the mixture. For instance, the melting temperatures of cyclohexane, benzene, and nitrobenzene are, respectively, 6.55, 5.50 and 5.70° at one atmosphere, but 58.7, 32.7 and 27.9° at 1,000 bars pressure.

Non-Uniform Compression

The processes illustrated above, wherein no attempt has been made to cover the whole field, are hydrostatic (uniform) pressure effects. There is another large field of very different pressure phenomena for which the compression is not the same in all directions (non-uniform) and not the same on all the reactants. Such compressed substances are said to be stressed.

The design of high pressure apparatus is in itself a study of non-uniform high pressure phenomena and these are therefore combined in the following discussion.

The experimental difficulties under which high pressure work is conducted are in general so different from everyday engineering experience that a large store of knowledge concerning the behavior of metals under extreme conditions has perforce been gained which might not otherwise be available to-day.

The growing interest in high pressure work is made evident by the rapidly increasing number of requests for assistance in design of apparatus. Publication of special assemblages is helpful, but, as no two problems are identical, it is more efficient and satisfactory to design the apparatus for the job rather than attempt to adapt an arrangement built for another type of work. There are certain fundamentals that must be fulfilled in any satisfactory construction, and some of these will now be discussed.

All the features of good engineering practice are adhered to where possible except that in experimental research safety factors are necessarily—although, it is hoped, intelligently—ignored where the ultimate in pressure is sought.

Apparatus for pressure work consists essentially of one or more steel vessels into which access must be had for pistons, connections, and electrically insulated electrodes.

Pressure Connections

Considerable attention has been given to seals for the various types of closures. They must be designed so that the stress developed *across* the contact surfaces making the seal between the interior and exterior of the vessel exceeds the pressure difference along the contact surface in order that the joints be leak-proof. For low pressure work this stress may be developed by tightening up nuts against the internal pressure. At high pressures this type of closure can be and is being made to function, but here the

[3] Imperial Chemical Industries (British): R. O. Gibson, E. W. Fawcett and M. W. Perrin, *Proc. Roy. Soc.*, A150: 230–240, 1935; M. W. Perrin and E. G. Williams, *Proc. Roy. Soc.*, A159: 162–170, 1937.

tightening must be done not with nuts but with continuous application of hydraulic pressure.

Seals which can be tightened up against internal pressures to 6,000 bars have been adapted from those designed by the Geophysical Laboratory, under the direction of L. H. Adams, for the Nitrate Division of the United States Ordnance Department in 1918. Such connections are now obtainable commercially and their use appears to be standard practice in this country to-day.

A simple but very effective method of making leak-proof connections, first used by Amagat and later developed by P. W. Bridgman and by the Geophysical Laboratory, can be adapted to a variety of purposes. Bridgman has named it the "unsupported area" principle. Some of these connections, chosen at random, are illustrated in Fig. 4. The unsupported area is the area exposed to the lower pressure side, and the differential closure stress is equal to the internal pressure times the ratio of the unsupported area to the packing area. If the closure stress is too high, failure will occur by shear or rupture of the packing stem, and if too small, the joint will leak. Moreover, for moving parts, such as pistons, the packing should be designed to have a minimum frictional drag. In this figure the arrows indicate the acting direction

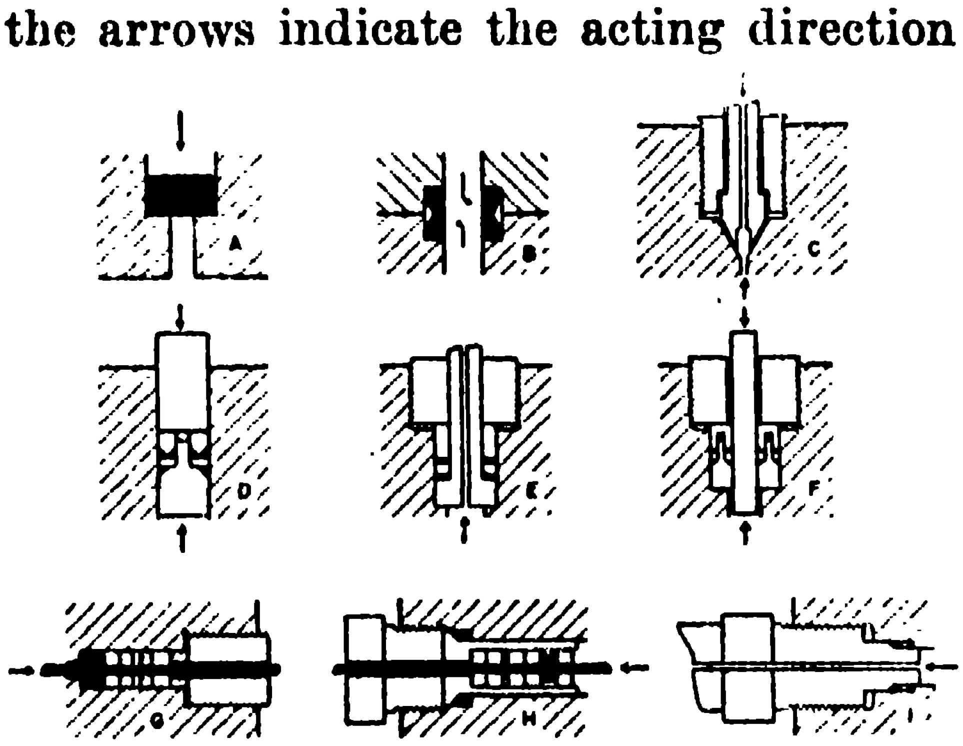


FIG. 4. EXAMPLES OF HIGH PRESSURE CLOSURES (A), CONNECTIONS (B, C, E, I), PISTON PACKINGS (D, F), AND INSULATED ELECTRODE PACKINGS (G, H).

of the internal pressure. Fig. (4, A) is the simplest example of such a closure which, in order to remain leak-proof, must have perfectly fitting contact surfaces. It was first used for glass windows in pressure vessels by T. C. Poulter.[4] Fig. (4, B) shows a joint seal made by a hardened ring with an outer cross-section in the form of a sine wave. To be leak-proof it must be a perfect fit, but this is easier in practice than with Fig. (4, A) because the contact surfaces can be made much smaller. Fig. (4, C) is an older but more generally useful variant developed by the Geophysical Laboratory. The two sealing surfaces are tapered at slightly different angles so that they are in contact only along a very narrow strip. The pressure load on the inner tapered bridge is transferred to the two supporting ends, one of which is the surface of seal. The sealing stress thus exceeds the leak pressure. The other packings shown here all have a fixed ratio of sealing stress to internal pressure, which means that at some value of pressure the packings will cut into and pinch off the adjacent metal. Seal (4, C) has the advantage that the contact surface increases and the unsupported area decreases by virtue of the bending of the tapered bridge with increasing internal pressure. It has been used for closures, packing plugs, dead-weight gage piston packings and pipe connections. All the rest of the packings listed here depend on the use of a plastic material which will flow into and close up any irregularities that may be present. Of these (4, D) is a piston packing in which the seal is made by using rubber together with rings of triangular cross-section which may be brass, phosphor bronze or beryllium copper, depending on the pressure. The purpose of these rings is to prevent the rubber from squeezing out of its allotted space. The unsupported area is given by that of the mushroom stem. Fig. (4, E) shows a

[4] T. C. Poulter, *Phys. Rev.*, 40: 860, 1932.

pipe connection sealed with rubber which is prevented from squeezing out by rings as indicated in (4, D); (4, F) illustrates a method of sealing around a moving piston. The packing materials are similar to those shown in (4, D). Fig. (4, G) shows an electrode packing made from lithographic limestone, talc and rubber; these also insulate the stem electrically from the metal container. Fig. (4, H) illustrates another form of electrode packing, but here the packing barrel, as far as the plug seal at the 45° incline, lies inside the pressure chamber and is thus supported by the internal pressure. Fig. (4, I) shows a pipe connection in which the plastic substance making the seal is retained by two steel rings; the unsupported area is here indicated by the triangular cross-section above the rings. Examples (4, C), (4, E) and (4, I) may also be used to seal up unused openings.

The maximum pressure that can be developed in an apparatus is determined by the strength of its materials. One of our problems is therefore concerned with a search for materials which, after preliminary temperature and pressure treatment, will meet the requirements. A pressure assembly consists of several different materials because the physical properties needed in the various parts are not the same and no one material has all the requisite characteristics.

High compressive strength is needed for pistons. Glass-hard tool steels have a compressive strength in the neighborhood of 30,000 bars. On the other hand, carboloy, which consists of tungsten carbide particles cemented with cobalt, is twice as strong as steel in compression and is thus the strongest known material under ordinary conditions. These materials are not homogeneous, however, and consequently are highly variable in behavior. It is deduced from certain theoretical considerations that, under different external conditions, described later, several other materials may become superior. Natural substances contain impurities and flaws so that a controlled synthetic product is desirable; one such substance is corundum, better known by the gem names ruby and sapphire.

High compressive strength is usually accompanied by the property of brittleness, so that for these materials there is practically no preliminary plastic flow before rupture under ordinary tension. Consequently, the presence of inhomogeneities and localization of high-stress regions in these substances prevent an even distribution of load over their cross-sections and they fail in tension long before the theoretical strength can be realized. A compromise must therefore be made in order to obtain sufficient ductility or plasticity to insure that these localized high-stress regions can be eliminated by redistribution before rupture occurs.

Considerable success has recently been attained in the Geophysical Laboratory with the use of certain ferrous alloys containing relatively large amounts of certain elements such as tungsten, chromium, vanadium, cobalt, and molybdenum. These alloys are subjected to a special kind of heat treatment which involves a delayed quench and repeated tempering draw. Under these conditions they become very hard and strong, yet exhibit a certain amount of ductility before failure; in other words, localized high-stress regions ordinarily present in hardened substances have been removed by this method of heat treatment without noticeably sacrificing hardness, an achievement not heretofore realizable with the older types of steels. This material is particularly adaptable for certain parts, such as the mushroom heads of pistons and electrode stems shown in Fig. 4, where the ultimate in both tensile and yield strength is desired.

Pressure Seasoning of Cylinders

When the inner bore layers of a pressure vessel are under internal pressure

they reach their elastic limit in tension before the exterior wall layers do, and this difference is accentuated by increase of wall thickness. If the elastic limit, or yield point, in tension is equal to the ultimate tensile strength, the cylinder wall ruptures from the *inside outward* without any preliminary warning. If, however, a considerable gap exists between these two stress limits the inner bore wall first yields plastically, *i.e.*, becomes permanently stretched, and transmits further increase of stress to the outer layers. This process can continue with further growth of the yield or plastic zone until this gap in the two properties becomes bridged at the bore wall or until the outermost layers become stressed to their tensile limit, whereupon the wall ruptures by tearing from the *outside inward* and gives warning by the stretch of its outer diameter.

To have the cylinder wall act as an elastic unit in supporting the internal pressure or, in effect, to increase elastic strength at the inner bore wall, an initial stress distribution must be set up such that the tangential, or hoop, stresses are tensions at the outer layers and compressions at the inner layers. This may be obtained by (*a*) shrinking thin sleeves one on the other to form a built-up cylinder, (*b*) wrapping wire under tension around the cylinder, (*c*) subjecting the vessel to a preliminary internal pressure seasoning, or "autofrettaging," in excess of the desired operating pressure, or (*d*) maintaining the interior wall at a higher temperature than the exterior wall.

This kind of preliminary treatment to prevent stretch in the bore diameter is essential not only for high-pressure cylinders but also for long-range guns in which high pressures are developed by the explosives. It may therefore be of interest to consider this technique in more detail.

The stresses set up in the walls of a steel cylinder with autofrettage pressure applied and with it removed are plotted in Fig. 5. The ratio of outside to inside diameter is three to one. The material is a cannon steel (technically, about S.A.E. 4,330) and one of the few for which quantitative calculations are possible because complete push-pull load-extension diagrams are available.

In this figure the cylinder cross-section is plotted with its axis horizontal, R_i denoting the internal radius and R_e the external radius. The radii R_p to R_i (the plastic zone) and R_y to R_p (the yield zone) are the regions wherein the stresses are above, and R_e to R_y (the elastic zone) the region below the yield point of the steel. The narrowness of the latter zone indicates that this cylinder is being frettaged close to its limit. The stresses set up with the autofrettaging internal pressure applied are plotted in the upper cross-section of the wall. The residual stresses after release of this pressure are plotted in the lower cross-section of the wall. Negative values of stresses or points lying to the left of the broken line are compressions, and positive values or those to the right are tensions. The stress "*S*," although actually hypothetical, gives a good account of the behavior of cylinder walls and, moreover, can be directly correlated with ordinary stress–strain tensile test measurements.

After such a preliminary pressure seasoning, the bore wall of the cylinder reacts elastically for internal pressures up to the frettaging pressure and is thus 2.5 times stronger elastically than the bore wall of the unfrettaged cylinder. An increased longevity of the cannon may be secured by a subsequent low temperature treatment to level off some of the high-stress points set up by the presence of inhomogeneities and impurities in the metal.

The gain in elastic properties of steel by proper heat treatment decreases with increase in thickness of the piece. Furthermore, the elastic resistance of a pressure vessel is limited by the residual

compressive stress that can be built up in the inner bore layers. This is less than the compressive strength as determined from test specimens because of the previous overtensioning in the autofrettage process. These two factors set a limit to the useful wall thickness of pressure vessels, but this may be removed in part by the use of built-up cylinders using some of the new materials now available.

Apparatus for High Temperature and Pressure Work

As was stated earlier, temperature and pressure are mutually antagonistic in their effects, but many important pressure relations can be studied only at high temperatures. Some of these are phase relations in silicate systems, *i.e.*, in the stuff that makes up the earth's crust, solubility and melting point determinations, electric and magnetic studies. Furthermore, some pressure reactions can be made to proceed only at high temperatures.

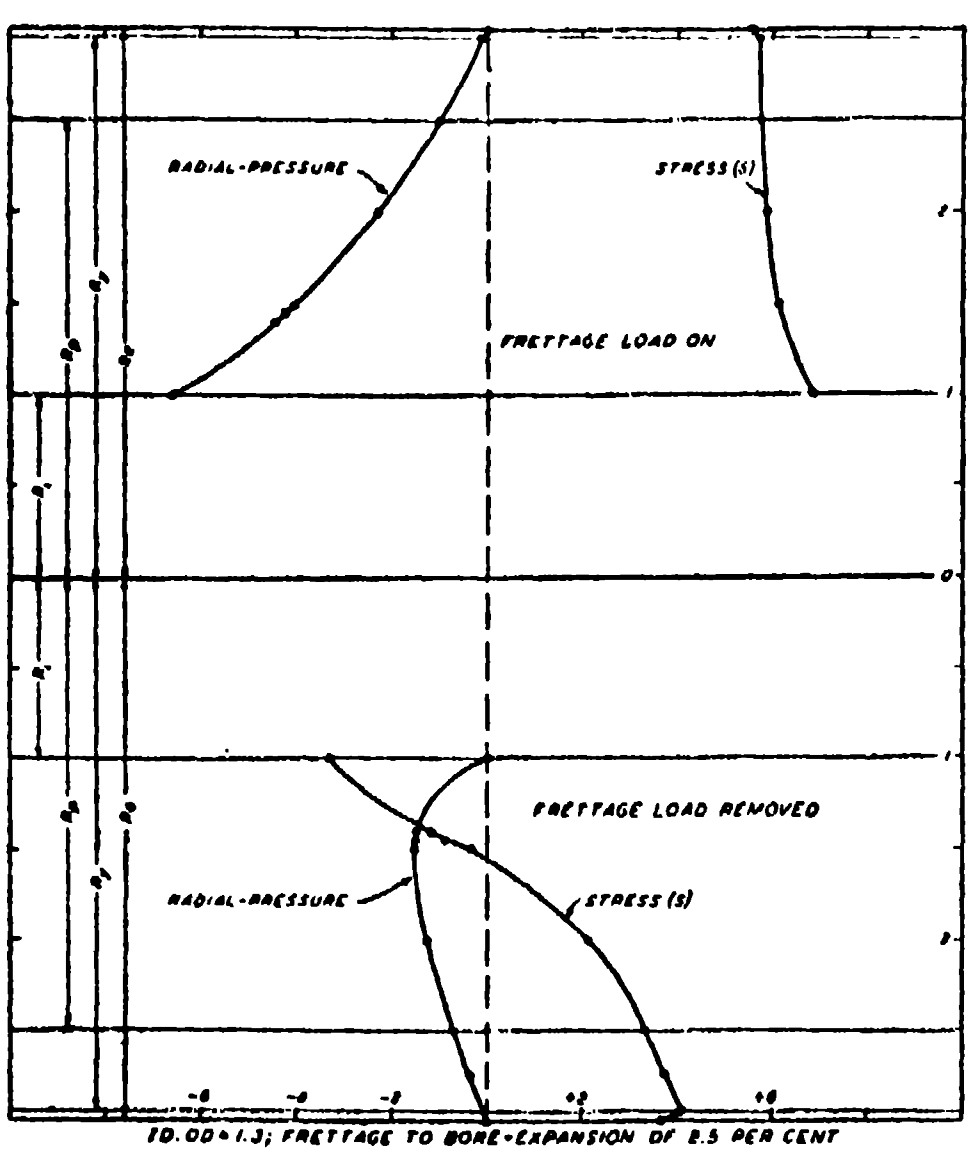


FIG. 5. STRESS DISTRIBUTIONS SET UP IN CYLINDER WALLS BY THE "AUTOFRETTAGING" PROCESS FOR HIGHER ELASTIC PROPERTIES IN PRESSURE VESSELS AND BIG GUNS.

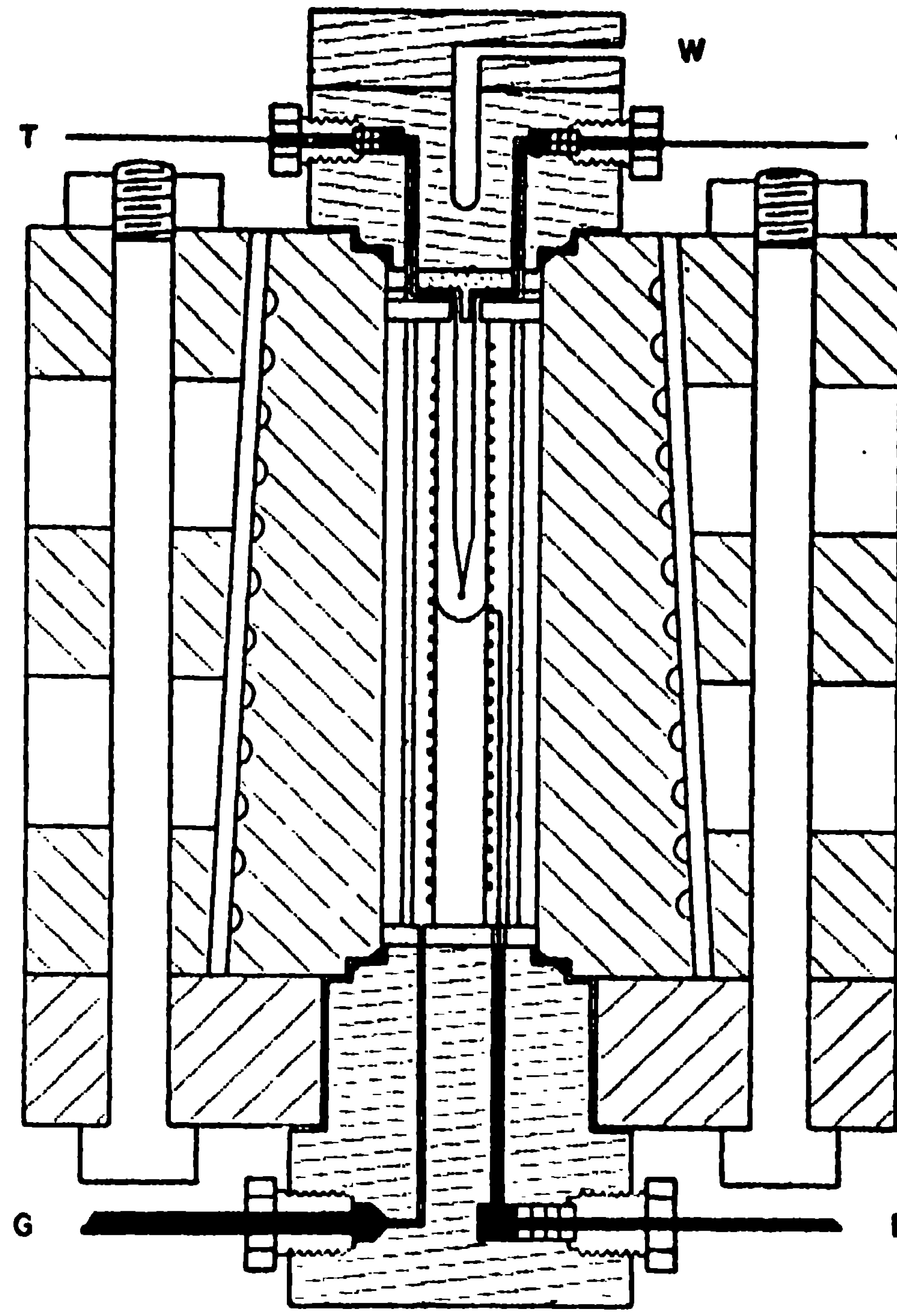


FIG. 6. CROSS-SECTION OF PRESSURE APPARATUS FOR WORK AT HIGH TEMPERATURES.

Operation with combined high temperatures and high pressures increases the practical difficulties enormously. For low temperature work the whole apparatus may be thermostated, but for high temperature work the walls of the steel vessel must be kept cool to retain their strength. Phase equilibria work has been carried out—in particular on silicate–water systems—to combined temperatures and pressures of 1.200° C. and 4,000 bars in an apparatus that was for a long time and may still be unique in the pressure field. Apparatus has also been designed for extending this high temperature work to pressures of 12,000 bars. A cross-section of such a high temperature-pressure apparatus is illustrated schematically by Fig. 6. It consists of a built-up cylinder capped at each end with lids. The provision for water-cooling channels as near the inner bore wall as feasible has resulted in a peculiar-

looking arrangement. Shrunk-on cylinders were used for a time but discarded for high temperature work because of the difficulty in correcting properly for the variable thermal gradients and other superimposed stresses in the walls. With this arrangement a fixed differential support may be obtained as indicated or varied at will by means of an additional hydraulic press similar to the device used by Bridgman for his coned cylinders. Electrically insulated electrodes are packed through the two lids. The lower ones feed current to a platinum-rhodium resistance furnace in the interior; the upper ones are thermocouples for measuring the temperature. The interior around the furnace is filled with reflection shields and thermal insulation material. The pressure medium is a gas fed in through the inlet "G."

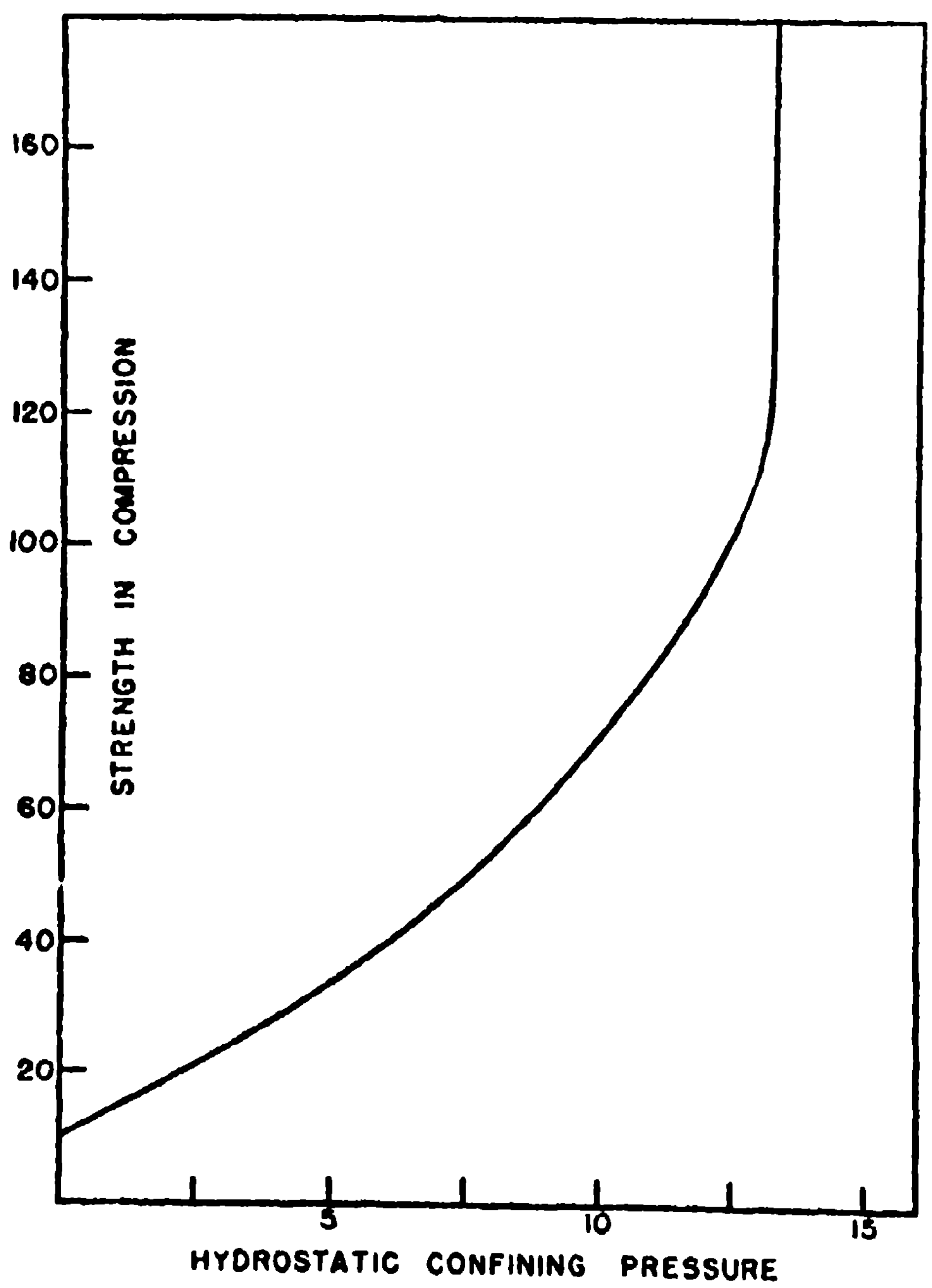


FIG. 7. CURVE OF ELASTIC COMPRESSIVE STRENGTH FOR IRON AT ABSOLUTE ZERO TEMPERATURE AS A FUNCTION OF HYDROSTATIC CONFINING PRESSURE COMPUTED FROM THE THEORETICAL MODEL OF GORANSON.

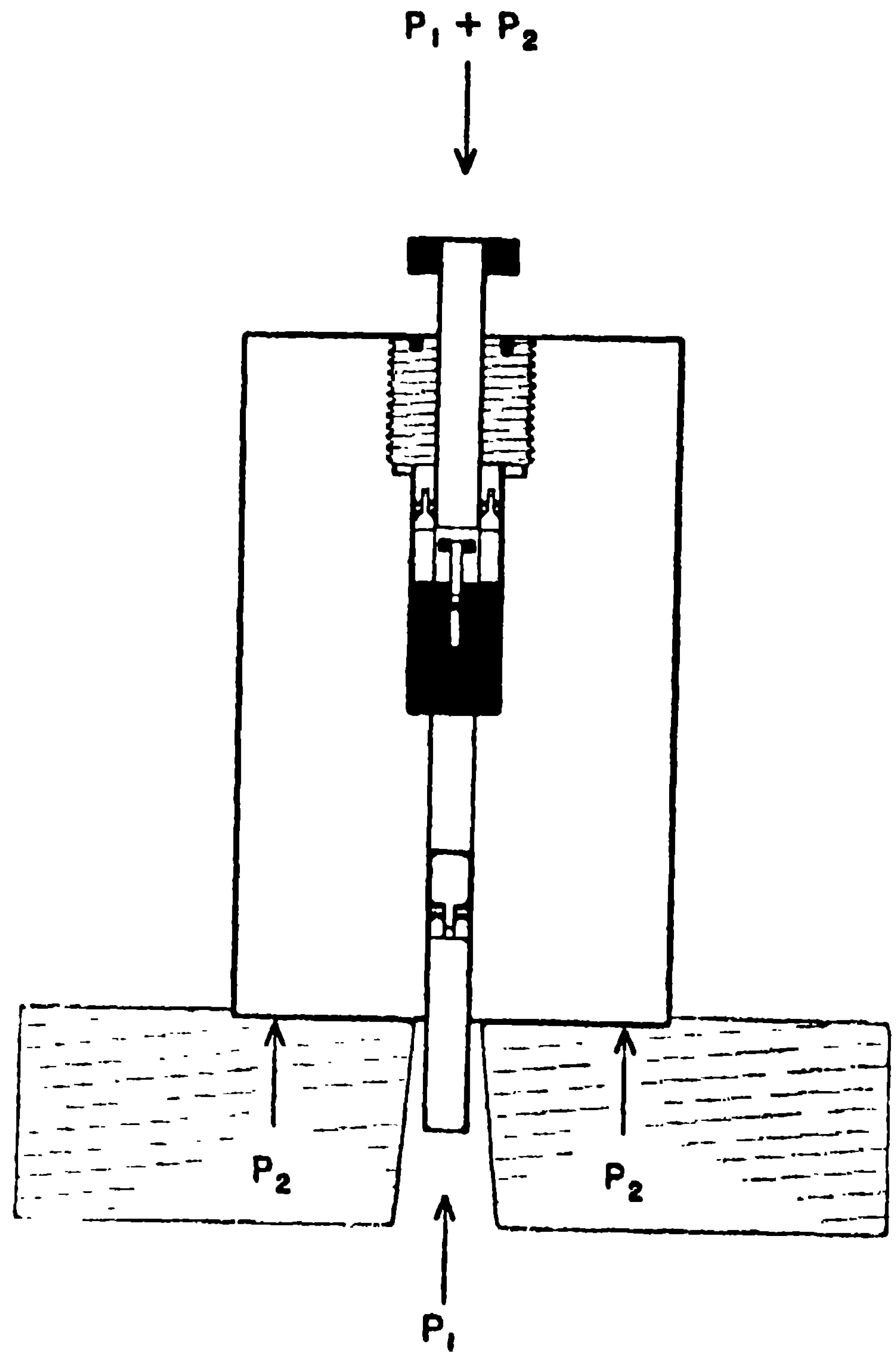


FIG. 8. CROSS-SECTION OF A CASCADED PRESSURE DEVICE CONSISTING OF ONE PRESSURE ASSEMBLY INSIDE ANOTHER. WITH IT PRESSURES TO 200,000 BARS HAVE BEEN BUILT UP IN THE INNER VESSEL.

Compressive Strength Under Hydrostatic Pressure

Pressure limitations of single stage apparatus will now be self evident. Many experimenters have undoubtedly contemplated the possible use of multiple-stage or cascaded pressure systems but have discarded the idea. The reason is very simple—any design based on an expected arithmetical increase in pressure per stage leads to such a bulky mutiplicity of stages that it would require an unlimited expense account to build the mechanism and a corps of people to assemble and operate it. It was not until the hypothesis of Goranson,[5] which predicted rapid increase of elastic compres-

[5] R. W. Goranson, *Jour. Chem. Physics*, 8: 323–334, 1940.

sive strength with increase in pressure of the surrounding medium, was sufficiently confirmed by experimental results, that construction of an apparatus based on such concepts was deemed worthy of consideration.

A curve of compressive strength as a function of hydrostatic confining pressure at zero degrees absolute computed for iron from this theory is plotted in Fig. 7. The interesting feature of this diagram is the shape of the curve which becomes infinitely steep at some finite value of confining pressure. This computation presupposes a perfect crystal, whereas in practice a solid will contain flaws, impurities and cracks, and may consist of a heterogeneous aggregate of crystalline grains. Under such conditions the first several thousand bars confining pressure will set up a non-uniform stress system by squeezing up on cracks and flaws in the structure. Consequently over this pressure region the increase in strength may be relatively small and perhaps even negligible. If the curve of Fig. 7 is modified to conform with certain assumptions made from these considerations it agrees closely with the experimental curves of David Griggs.[6]

The above discussion has reference only to the elastic strength but a solid may also fail by "plastic flow," a change-of-phase mechanism given by the free-energy relations mentioned earlier. The ease with which a material will flow under compression is, for constant test temperature, roughly proportional to the reciprocal of the absolute melting temperature. If, then, the confining pressure is high enough, a solid under compression can fail only by flow, and this condition sets an upper limit to the fundamental strength for temperatures above the absolute zero.

[6] David Griggs, *Jour. Geol.*, 44: 541–577, 1936; (with J. F. Bell) *Bull. Geol. Soc. Amer.*, 49: 1723–1746, 1938.

Apparatus for Work at Very High Pressures

A simple two-stage cascaded arrangement of pressure vessels is illustrated by Fig. 8. The first-stage pressure vessel has two pistons and pressure P_1 is developed in it by forcing up the lower piston. The first-stage pressure medium surrounds and acts on the exterior of the inner second-stage vessel and its piston. When the desired P_1 has been obtained the lower piston is kept fixed with respect to the upper piston. The outer pressure vessel is then lifted up against the upper piston which engages with and forces down the piston of the second-stage vessel. Since the upper piston and cylinder bore of the lower piston have the same diameter, P_1 remains constant during this latter operation. The pressure acting on the second-stage piston is equal to the ratio of first- and second-stage piston diameters squared and multiplied by P_2 less the friction.

Concluding Remarks

In this paper an attempt has been made to indicate, with some examples, what kinds of changes may be expected at higher pressures. Attention has also been called to the present limitations of theoretical physics in predicting very high pressure phenomena from low pressure measurements. Design of apparatus for very high pressure investigations has been discussed not only for its own sake but also because it illustrates the very interesting field of non-uniform pressure phenomena.

The writer has drawn freely from knowledge gained in his long, close association with Mr. L. H. Adams, director of the Geophysical Laboratory, and with Professor P. W. Bridgman, of Harvard University. He also wishes to express his appreciation to Mr. C. J. Ksanda, who prepared the diagrams for this paper.

THE STUDY OF HUMAN HEREDITY[1]

By Dr. LAURENCE H. SNYDER

PROFESSOR OF ZOOLOGY, THE OHIO STATE UNIVERSITY

ONE of the most interesting biological developments of the past decade has been the increasing realization of the importance of a knowledge of human heredity in everyday life. Of course a certain respect has been paid to heredity for a long time. The considerations given matters of birth, family background and race testify to this fact. It is only recently, however, that we have had any exact knowledge of the transmission of factors for diverse characteristics from generation to generation in human beings.

When the laws of heredity were discovered, tested and finally understood in experimental plants and animals, it was inevitable that the attention of the geneticist should be drawn to the study of similar phenomena in man. Gradually a body of knowledge on the genetics of man has been built up, and, as always happens when sufficient basic facts are accumulated, a series of practical applications has appeared.

The first of these practical applications involves the physician, who may find a knowledge of human heredity of value in diagnosis, especially early diagnosis. Instances are on record in the medical literature involving telangiectasis, polycythemia vera, spina bifida, orthoglycemic glycosuria, multiple exostoses and others, where the proper diagnosis was not made until the genetic background was taken into account. In the next paper in this series, Dr. Macklin will discuss this application in detail.

A second practical application of a knowledge of human heredity consists in the outlining of preventive measures as a result of the examination of the family history of the patient. Tests for preclinical and laboratory signs of a disease which has a genetic basis may be made in the relatives of affected individuals, and proper preventive measures instituted where indicated, before the condition becomes acute. This is being done by many physicians in cases of pernicious anemia and its antecedent achlorhydria, in certain types of cancer, in hemolytic icterus, in hypertension, in diabetes and in other cases where a genetic background is known.

A third practical application involves the lawyer. In recent years the heredity of several substances (antigens) found in human red blood cells has been carefully worked out. On the basis of this knowledge a man falsely accused in a paternity case may be cleared of the charge in certain instances. In a later paper of this series Dr. Wiener will discuss problems of this nature.

As a fourth practical application of a knowledge of human heredity, such knowledge may furnish the basis for advice on prospective marriages. It is a common experience for the geneticist to be asked "What are the chances that this trait which is in my family background will appear in my children?" Sometimes it is a trait which the individual may be desirous of having in his children, such as musical ability, intelligence or red hair. At other times it may be an unwanted trait such as feeble-mindedness, dementia praecox or deaf-mutism. When such questions are asked, the geneticist must call on his knowledge of the trait concerned, the possible genetic

[1] This is the first of a series of eight articles, each by a different author, on various aspects of human heredity. The general plans for this series of articles were prepared by Dr. Snyder at the request of the Editors.

basis, the variability caused by different environments, and from this composite picture reach some answer. Frequently the answer must be vague and unsatisfactory because there is not enough exact knowledge concerning the parts played by heredity and by environment in the production of the trait. Sometimes, however, where such knowledge is at hand, valuable information may be given.

In a recent case a hemophilic patient with a typical family history of the disease stated that his three daughters had not been told the nature of his affliction, nor were they to be told, since he was ashamed of the hereditary blemish, as he considered it. Yet if these daughters marry, half their sons will be expected to have hemophilia, a condition which proves fatal in childhood in the majority of instances. Advance knowledge of the chances of hemophilia in these families would at the very least make it possible for the mothers of sons to have everything in readiness for an emergency transfusion at any time.

In another case, a girl blind from aniridia was amazed to learn, upon consulting a geneticist, that half of her children of both sexes would be expected to have the abnormality.

Fifth, a knowledge of human heredity may furnish the basis for advice on prospective pregnancies. A young man recently came to us for advice on a family history of psoriasis, a skin disease. His father and grandfather had the disease, as did several brothers and sisters and some nieces and nephews. The young man's wife was then pregnant. After becoming pregnant she had learned of and seen the skin affliction of her husband's relatives, which, in the case of the girls and women, prevented the wearing of sleeveless or low-necked gowns. The young wife became obsessed with the idea that her child would have psoriasis. It preyed on her mind to such an extent that she was in danger of a nervous breakdown. Close examination of the family history revealed that in this family the psoriasis never appeared in a child unless one of the parents showed it. Only certain members of each family showed it, although all came in contact with it. It was apparently behaving as a dominant character. Since the young man in question was entirely free from the disease, it was possible to assure his wife that there was no danger of the child's inheriting the condition.

Sixth, a genetic knowledge can provide the necessary information for setting up eugenic and euthenic programs for the protection of society, a problem in which every citizen should be able to take an intelligent part, based upon experimental data, not on opinions, prejudices or the exaggeration of the uncertainties.

Seventh and last, there is every indication that with the discovery of more test factors of the sort exemplified by the blood agglutinogens, the taste deficiencies and others which can be determined in early childhood, we shall eventually be able to predict in children the probability of the occurrence of latent genetic diseases and abnormalities which may prove to be closely linked in inheritance with such test factors.

The various kinds of hereditary behavior now known are so complicated that their understanding requires a certain amount of study. This means that no one is justified in stating on his own responsibility that a given trait in man is or is not conditioned by hereditary factors unless: (1) He is thoroughly familiar with the known kinds of hereditary behavior. (2) He is familiar with the character under discussion in all its varying manifestations. (3) He has carefully investigated the character in a scientific manner from a genetic standpoint. This often involves the cooperation of geneticists, physicians, dentists and psychologists.

As in other sciences any hypothesis of

heredity, besides accounting for the facts at hand, must stand the acid test of predictive value.

In order to apply a knowledge of heredity to practical problems in human beings, certain fundamental conclusions must be granted. Among the conclusions taken for granted in the application of genetics to man are the following:

(1) The biological basis for the dozen or more major kinds of hereditary behavior has been adequately established by experimentation in animals and plants.

(2) Man fulfils the biologic requirements for being subject to the same laws of heredity as other organisms. (Among these requirements are sexual reproduction, a chromosome mechanism in which the chromosome number is reduced to half in the sperms and eggs, physiologic processes similar to those of other organisms, etc.)

(3) Hereditary factors are associated with the chromosomes. The evidence for this now amounts to what is practically a complete proof.

(4) Mental traits have their basis in physico-chemical structure, and are susceptible to the same laws of heredity as other characters. (Mental traits will be discussed in this series of papers by Dr. Penrose and Dr. Burks.)

(5) Heredity and environment are cooperative in the production of any finished character. One or the other influence may in certain circumstances appear negligible, but the dual nature may always be demonstrated.

Let us turn for a few moments to the principles involved in the analysis of human pedigrees.

The transmission of diverse hereditary factors from one generation to the next involves a series of phenomena resulting finally in the visible expression of characters in observable ratios. Most of the events in this series develop in direct consequence of the laws of probability, the probabilities being exactly determinable, thus making genetics more readily amenable to mathematical analysis at the present time than any other biological science. The included phenomena are as follows:

(1) *The segregation of factors into germ cells.* Segregation involves the separation of the two members of a pair of factors when germ cells are formed so that one member of the pair goes to one of the resulting cells, the other member to the other. Thus half the germ cells will normally contain one factor of the pair, half the other. If the two members of the pair of factors are different, so that the individual is said to be heterozygous for that pair, the germ cells will be of two sorts, in equal numbers, in regard to that pair of factors. Thus the probability that any given germ cell of a heterozygous individual will contain a particular factor is one half. However, abnormal segregation is known, in which certain factors do not separate from each other, thus changing in these instances the probability of a given germ cell containing a particular factor.

(2) *The assortment of factors during segregation.* If an individual is heterozygous for two or more pairs of factors, the factors segregate at random if they are located on different pairs of chromosomes. Thus, in regard to two pairs of factors, four kinds of germ cells will be produced in equal numbers; in regard to three pairs of factors, eight kinds in equal numbers, and so on. The chance of a given cell containing any two particular factors is therefore one fourth, any three particular factors, one eighth, and so on. However, if the factors are located on the same pair of chromosomes (in which case they are said to be linked) these probabilities are altered, roughly in proportion to the relative distance between the two pairs of factors on the chromosomes. This distance determines how often the factors may assort

at all, the assortment approaching a random one as the relative distance increases.

(3) *The type of mating.* When a population consists of various sorts of individuals, there will be, of course, various sorts of mating possible. The kinds and proportions of germ cells available for fertilization in any particular mating will depend upon the genetic composition of the individuals involved in the mating. Mass matings in a population may be at random or may be assortative (that is, certain types of mating tending to occur to the exclusion of others). The probabilities for various kinds of offspring depends among other things on the type of mating.

(4) *The frequencies, in the population, of the genes concerned.* The two members of a pair of factors may be equally distributed in a population, or one may be common and the other rare. The relative proportions can be determined by the use of certain mathematical technics, and are of importance wherever mass matings are concerned. Moreover, the frequencies of the two members of a pair of factors may have reached an equilibrium in the population, or they may not yet have done so. This too may be deduced by special methods. Gene frequencies and equilibria become of especial importance in the modern analysis of human pedigrees, and will be further discussed later in this paper as well as by Dr. Cotterman in a subsequent paper.

(5) *The union of the germ cells.* Fertilizations normally occur at random, that is, any sperm has an opportunity equal to that of any other sperm of fertilizing a particular egg; conversely, an egg has a probability equal to that of any other available egg of being fertilized by a particular sperm. Here again, however, exceptions occur, and cases of selective fertilization are known. In such cases the probabilities are of course shifted.

(6) *The interaction of factors, during development, with each other and with the environment, resulting in observable characters (phenotypes).* The characters finally produced and the proportions in which they are produced will depend upon this and the preceding five phenomena. These phenomena, serially taking place from generation to generation in specific environments, give rise to the phenotypic expressions of characters in definite ratios, from the analysis of which the laws of heredity have been deduced.

The type of inheritance involved in any particular case, the number of pairs of factors concerned, the mode of interaction and other relevant conclusions have long been determined from the study of the phenotypic ratios derived from specific types of mating. The classical genetic analyses of animals and plants have necessitated the scrutiny of at least three generations (parents, F_1 and F_2). Often additional generations (back-crosses, F_3, etc.) have been required. As long as such planned matings were readily made, there was no necessity of searching for other types of analysis. With the growing interest in the study of human inheritance, however, it was increasingly realized that the classic methods could not serve in this field. It became imperative to devise technics which would obviate the necessity of knowing the precise genotypes of the parents, and which would eliminate the need for the study of F_2 generations, back-crosses, etc.

Once the need was felt, the technics were not long in appearing. In general, such technics are based primarily on derivations of the frequencies of the genes in the population, the derivations being made from the frequencies of observable phenotypes. On the basis of such gene frequencies, the results of various mass matings may be predicted. The many methods now available have originated in scattered laboratories. Contri-

butions to this field have been made in England by Fisher, Haldane, Hogben, Penrose and others; in Germany by Bernstein, Lenz, Wellish and others; and in America by Burks, Wiener, Wright, Cotterman, Rife, Snyder and others. In the course of the development of methods for analyzing human inheritance the number of generations required for the analysis has been reduced first to two, and finally to but one, while the requisite knowledge of the precise genotypes of parents has been gradually reduced and finally eliminated entirely.

It must not be thought that methods which lessen the required number of generations available for study or which minimize precise genotypic knowledge concerning parents are more desirable or more efficient than the classic methods. It is merely that they must serve, as efficiently as possible, in a field in which test matings of precisely known genotypes are not available.

It will be readily seen that no single method can answer all the questions about the genetic bases of human characteristics. Various technics are concerned in solving the problems as to the number of pairs of factors involved, whether these factors are acting as dominant, recessive, blending, sex-linked, sex-influenced, lethal or multiple factors, whether or not epistatic relationships are present, and whether the factors are linked or independent. In predicting the proportions of different types of offspring to be expected from various mass matings involving specific phenotypes, complications arise in that a single phenotype often includes several different genotypes. In linkage studies a heterozygous genotype may include both coupling and repulsion phases. Hence it is necessary to provide suitable statistical corrections and allowances, since in human data such complications can hardly be avoided. The philosophy of the mathematical approach to the study of human inheritance will be presented by Dr. Cotterman in a subsequent paper.

One of the points most frequently overlooked in the study of human heredity is the matter of equilibrium in gene frequencies. It should now be a commonplace that equilibrium in regard to the genotypes resulting from a pair of autosomal factors exists when the homozygotes for one allele, the heterozygotes and the homozygotes for the other allele are in the relative proportions p^2, $2pq$ and q^2, respectively, where p and q are the frequencies of the two alleles so that $p+q=1$ and p or q may have any correlative value from 0 to 1. Moreover, if anything occurs to displace the equilibrium, a new equilibrium is reached after a single generation of random mating. For sex-linked genes, epistatic interactions and other complicated cases, equilibrium may be reached more slowly.

Self-evident as these propositions would appear to be, misunderstandings of them and of their implications are all too frequent in discussions of human heredity. It is often said, for example, that a dominant character increases in the general population at the expense of its recessive counterpart until it stands in the ratio of 3:1. This statement has no basis in fact. A recent text states that "albinism is due to a recessive factor, *which explains why it is so rare*" (italics mine). Another book, a treatise on handedness, proclaims that "left-handedness occurs in 25 per cent. of the population, *which indicates that it is a Mendelian recessive*" (italics mine). Each of these statements shows a complete lack of understanding of the principles of equilibrium.

A recessive character may be common or rare in a population, depending upon the relative abundance or scarcity of the hereditary factor determining the character. Split hand, or "lobster claw," in which the hand has only two large fingers, is due to a dominant factor, the

normal complement of five fingers being due to its recessive allele, yet the recessive character is the common condition. Recessive characters may occur in various populations in any frequency whatsoever from 0 to 100 per cent.

A recent prize-winning essay of the Eugenics Research Association contains this remarkable pronouncement: "We are indeed lucky that the mental disorders or psychoses are not dominant traits, or we would all be insane by now, according to the laws of heredity." In a recent manuscript on finger-prints which I was requested to read and criticize appeared the following paragraph:

> Here we have a pattern (arches) which when crossed with another of the same classification, produces its own kind, plus loops and whorls. This reaction seemed to fit the requirements of a character heterozygous in the parents and segregating in the 1: 2: 1 ratio. A check on the frequency of arches in the general population quickly invalidated such a supposition, however, for it was found that only about 5 per cent. of all patterns are arches. Support for such an idea would require 25 per cent. loops, 50 per cent. arches and 25 per cent. whorls. Some other explanation was therefore necessary.

Here again we have examples of complete misunderstanding of gene frequencies and equilibria.

I have belabored this point because the lack of attention paid to these important considerations has greatly retarded the progress of the study of human genetics. The necessity for a thorough understanding of the unique problems involved in the genetics of man must be appreciated before further progress can be made. Some attempt at creating such an understanding will be made in this series of articles.

Among the problems facing the student of heredity in man, many of which will be considered in detail in later papers of this series, are the following: to test the linkage relations of known human genes and to construct maps of the human chromosomes by the use of the newly elaborated paired-sib technic; to search actively for new genes in man; to further elaborate the gene-frequency technics and other statistical methods for the analysis of hereditary human factors; to determine the phenotypic frequency of various traits in the population—in other words to take a census of human traits; to establish and maintain twin clinics in qualified hospitals; to study intensively the genetic and environmental influences interacting in the production of "mental" characters; to obtain relevant facts about the genetic and environmental backgrounds of socially significant traits of all sorts; and finally to create an awareness of the importance of the genetic viewpoint among physicians, social workers and the general public.

It is the hope of the student of human genetics that such a cooperative line of research may eventually give rise to a social edifice, the foundation of which is made up of substantiated facts about the development, both from a genetic and an environment standpoint, of human characteristics, and the superstructure of which is a tower of eugenic strength which can be defended against any attack. To this end we bespeak the cooperation of biologists, physicians, anthropologists, psychologists, sociologists, legislators and social workers, and we ask the continued faith and support of the public.

GERMINATION OF SEEDS

By LELA V. BARTON

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EVERY one who has had experience in the germination of seeds has encountered difficulties at one time or another. If the seeds possess a dormant embryo, as is the case for many of our temperate zone plants, especially trees and shrubs, there is a very definite and simple procedure which may be used to bring about germination. If, on the other hand, the embryos are not dormant, but the seeds still fail to germinate under ordinary conditions, some other special treatment must be given. Some of these peculiarities are exhibited by our very common seeds.

Certain specific temperature conditions are necessary for the germination of many forms. For example, wild columbine seeds germinate very poorly at a constant temperature as high as 77° F., but give excellent germination if the daily temperature alternates between 59° and 77° F. Annual delphinium or larkspur seeds show very poor seedling production at temperatures above 58° F. but can be induced to germinate at temperatures as high as 86° F. by pre-treatment on a moist medium for one, two or three weeks at temperatures of about 50° or 59° F. Lettuce seeds can also be made to germinate at high temperatures normally inhibitive by pre-treatment for four days in a moist condition at 41° F.

The difficulties encountered by many rock garden enthusiasts in the germination of seeds may be attributed to any one of several factors. Seeds of *Primula obconica* and *Ramondia pyrenaica* require light for germination. Although light is not essential for the germination of seeds of *Draba aizoides, Gentiana lagodechiana, Mimulus langsdorfii* and *Primula denticulata,* exposure of all these seeds to light during the germination process permits seedling production at temperatures ordinarily inhibitive. Other rock garden plants, such as *Calochortus macrocarpus, Camassia leichtlinii* and *Lewisia rediviva,* germinate only at low temperatures of approximately 41° F. Still another group of rock garden plants, including *Draba alpina, Meconopsis cambrica* and *Gentiana crinita,* possess dormant embryos and must be pre-treated at low temperature, after which germination proceeds at ordinary greenhouse temperatures.

Many weed seeds not only show a delay in germination but are capable of distributing their seedling production over a period of years. This fact is demonstrated repeatedly by the years of cultivation necessary to get rid of weeds in a garden plot, even if care is taken to eradicate all weeds as they appear and to prevent the introduction of new weed seeds. The soil contains many dormant seeds which produce plants promptly when cultivation, excavation or erosion gives them the moisture, temperature and oxygen supply or the exposure to light required for germination.

The survival advantage to the plant of delay in germination, due to specific requirements, is further demonstrated by the behavior of the seeds of certain winter anuals growing in desert regions. The germination of these seeds immediately after harvest, when the seedlings could not survive because of the heat, is prevented by the requirement of comparatively low temperatures, or combinations of low with moderately high temperatures, for germination. An additional protection is the dormancy exhibited by freshly harvested seeds of these forms. This dormancy disappears

by the second summer rainy season when the seeds germinate and the seedlings grow.

Dormancy in freshly harvested seeds is also prevalent in some of our common cereals such as wheat, barley, rye and oats. This is an advantage to the farmer in that there is no loss of grain due to germination in the shock. Seed-testing stations, on the other hand, find this character a decided problem in testing cereal seeds for germination capacity, since at the temperatures normally used for tests, only the non-dormant seeds germinate. They have found, however, that all the viable seeds, both dormant and non-dormant, will germinate at approximately 50° F., so that a good index of the real germination capacity can be obtained at this temperature. Similarly, testing laboratories have used daily alternations of temperature as well as light to determine the germination value of seeds of some of the grasses of meadow and pasture.

Still other seeds fail to germinate because of hard coats which prevent the absorption of water. These seeds are especially common in the legume family. Sweet clover, alfalfa, wistaria and locust are some of the forms which produce hard-coated seeds. Several methods have been developed for making these coats permeable and thus bringing about germination. Among these are hot water or sulfuric acid treatments, filing and passing the seeds through abrading machines. The last method permits the treatment of large quantities of seeds.

The seeds of varied and numerous temperate zone plants possess dormant embryos. One of the best-known methods for bringing about their germination is that of low temperature pretreatment, generally known as "stratification." This process consists in placing the seeds in some moist medium, such as granulated peat moss, sand or soil, and placing them at 33°, 41° or 50° F. for certain periods of time. From one to several months in this condition is required for after-ripening the seed. At the end of the low-temperature or after-ripening period, the seeds will produce seedlings promptly in the greenhouse. In nature, the winter supplies the low-temperature period, so that, if the seeds are moist, they are after-ripened and prepared for germination the following spring. Seeds of water plants as well as those of land plants are affected. Water plantain, wild rice, bulrush, fringed gentian, wintergreen, bittersweet, flowering dogwood, spruce, pine, bayberry and roses are among those plants having seeds which respond to stratification at low temperature.

An increasing number of seeds are being found to possess both hard or resistant coats and dormant or partially dormant embryos. To remove the inhibition of germination in these cases, it is necessary first to remove the coat effect and then pre-treat at low temperature in order to after-ripen the embryo. Seeds of this type, if planted in a moist medium at a warm temperature (68° to 86° F.), will be attacked by bacteria and fungi which cause the partial degeneration of the hard coats. The length of time necessary for this action has been found to vary from 30 to 120 days, depending on the species. At the end of this period, a transfer of the culture to low temperature will after-ripen the dormant embryo, after which germination will proceed at ordinary greenhouse temperatures. The coat restriction may also be removed by any of the treatments described above for hard-coated seeds. Some of the seeds requiring this treatment are bearberry, snowberry, basswood and certain species of cotoneasters and hawthorns. Such seeds can be handled practically by planting in the spring or early summer in a temperate climate. The coats will deteriorate dur-

ing the summer, the embryos after-ripen during the winter and the seedlings appear the following spring.

Certain seeds produce a root readily when exposed to ordinary temperatures for germination, but they fail to produce shoots if kept continuously at those temperatures. Here, it is necessary to expose the germinated seed, with the root system beginning to develop, to low temperature (33° to 50° F.) for a while in order to after-ripen the epicotyl or the bud that forms it. A number of the "two-year" lilies, the tree peony and the high bush cranberries exhibit this type of dormancy. All seeds of this type have been known as "two-year" seeds. However, they can be made to produce seedlings the spring after harvest by planting them in flats in a greenhouse, where they should be allowed to remain until root systems are formed. The flats should then be transferred to low temperatures for one-half to four months, depending on the species. Practically, these seedlings may be produced in the same way as those in the preceding category, that is, by spring or early summer planting. For example, seeds of *Lilium auratum* planted outside in April or June in the region of Yonkers, N. Y., gave good seedling stands the following spring. The warm months during the summer permitted the emergence of the radicles and the development of the root systems, while the succeeding cold of the winter months broke the epicotyl dormancy. Plantings made as late as August produced very few seedlings the following spring, since the warm period was too short to permit root formation. The flats were kept in a board-covered frame over winter.

Many of the seeds which are favorably affected by low temperature pre-treatment exhibit a partial dormancy of the embryo. When these embryos are removed from the coats and placed in germinators, they grow very slowly and the tops produced by such seedlings are dwarfed. Artificial dormancy is thus induced. This condition has been reported for the Japanese rose tree, peach, apple and hawthorn, all of which belong to the rose family. If grown at 62° F. or above, they remain dwarfs for six months to a year and a half, after which one or more buds start to grow. On the other hand, if, at any time, the dwarfs are exposed to 41° F. or lower for two months, the secondary dormancy is overcome and vigorous growth follows promptly upon removal to a higher temperature.

Seeds with dormant embryos have contributed their share to the problems of seed-testing laboratories. If the germination methods described above, including months in stratification at low temperature, are used, the viability may be obtained. In many cases, however, it is desirable to know quickly whether a certain seed lot is worth purchasing or planting. As a result, many methods for rapid testing have been devised. One of the most successful of these consists in removing embryos and placing them on moist filter paper in Petri dishes. Within a week or two, the live embryos enlarge and, in light, become green, while the dead ones become brown and decay.

Although many of the problems in seed germination have been solved, new ones are being encountered daily by seedsmen, gardeners, florists, conservationists and others to challenge the workers in this field.

FREE ENTERPRISE AND SCIENTIFIC DEVELOPMENT

By RUFUS S. TUCKER

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THE phrase "free enterprise" is commonly used to designate the system of economic organization that has flourished from the early nineteenth century until recent years in the most prosperous and progressive nations. This system has many other names. Adam Smith called it the "system of natural liberty," although when he wrote it did not exist except in the imagination of thinkers like himself. It has been called, in praise or dispraise, the system of *laissez-faire*. Other names, referring to parts of the system rather than to the whole, are "the competitive system" and the "price-system," or sometimes merely "capitalism." Whatever its proper designation, it is admitted by friends and foes to have been responsible for, or at least to have permitted, a more rapid increase in the productive efficiency of the human race and in the standard of living of the common man than has been recorded in any previous period of equal duration.

At first sight this seems strange, for the outstanding feature of the system is that it is not based on any one's conscious desire to serve the social interest or to raise the standard of living of any one but himself and his family. How has it worked to bring about this result?

The essential details of the system of free enterprise are: (1) that every individual is permitted to use his own resources and those voluntarily entrusted to him by other individuals to produce goods or services; (2) that these goods or services are offered for sale in competition with other goods or services; (3) that customers indicate their preference and the relative intensity of their wants by the price they are willing to pay for each product; (4) that the producers who have successfully gauged the customers' demand and are able to produce at a cost less than the price they can obtain, make money and, in consequence, increase their output, while other producers lose money and are compelled to reduce their output or improve their methods. What and how much shall be produced is determined by the way the public spends its money. Who and how many shall produce are determined by the number of persons with sufficient skill, capital and daring to produce at a price low enough to give them a share of the market. What price shall be charged is determined within limits which are usually very close, the lower limit being set by the cost of production of the least efficient producers whose supply is necessary to satisfy the demand, and the upper limit, which is rarely reached, being set by the price of some substitute object of expenditure. It will be observed that there is in this scheme no place for an authority to determine who shall produce what or what price shall be charged. There is no compulsion—only persuasion. Prices are the governor of the free enterprise system.

The alternative to the system of free enterprise is what is known as "planned economy." Free enterprise is, of course, a plan for the economy, a plan for decentralization and individual responsibility. However, as the phrase "planned economy" is commonly used it means the direction of all or a large part of the economic activities of the nation by the

government or by some organization controlled by the government and endowed with quasi-governmental powers. Since any body that controlled the economic activities of a nation, and had, in addition, the powers already possessed by government, would be able to control the total of human activities, planned economy as outlined by its leading advocates is merely a modification of totalitarianism, phrased in language not so shocking to the ears of free men as the language of Communism and Fascism.

The system of free enterprise resembles the political system that we have known as democracy in that it is based on persuasion. The purchaser is the voter who determines who shall produce and his vote is influenced by advertising as well as by recollections of previous services rendered. But producers have no power to coerce the public, whereas politicians once elected do have that power. As long as the politicians are limited in the scope of their activities their coercive power may be beneficial. We do not mind coercing criminals; we do not even object to coercing taxpayers if the taxes are spent for purposes generally approved, and without excessive waste. But if politicians were given the right to produce goods or to regulate in detail the activities of producers, their power would be enormously increased. We should have substituted coercion for persuasion in the production and distribution of goods. That in turn would strengthen the power of the politicians in the fields they already controlled. The constitutional and customary barriers protecting minorities would be broken down. Because of the apparently greater efficiency of a single executive the rights and duties of the legislative body would be forgotten. The forms of democracy might be preserved but the substance would be gone. Students of ancient history are well aware that the senate and consuls of Rome were regularly elected and went through the motions of legislation and administration for 300 years after Augustus established the Empire, while, officially the Emperor was only the commander of the army, the ruler of certain provinces and the leading citizen of Rome.

The totalitarian or authoritarian systems have varied considerably in their political structure. Some have been absolute monarchies based on a claim of divine right. Some have been oligarchies, some theocracies, some, ostensibly, democracies. Nearly all have claimed to be acting in the interests of the whole people. In fact, it would be almost impossible to find a dictator who did not claim to be the true friend of the people and who did not try to prove that friendship by conspicuous acts of generosity, frequently at the expense of his political opponents. But real democracies—unless the term is used as synonymous with the tyranny of a demagogue—are inconsistent with governments of unlimited powers. The rights of minorities, the liberty of individuals to control their own activities within wide limits, freedom of speech and of the press—in other words, all that has made what we know as democracy dear to the hearts of Americans— can not be maintained under a government that asserts broad powers over economic activities. In the name of efficiency, all opposition to the plans of the government must be suppressed, and it is an easy and inevitable step to suppress those varieties of scientific and religious thought that meet with the disapproval of the dictator, even if they are not directly and closely connected with economic activities. The hand of the state will reach all the corners of society, and all research will be devoted to proving that the government is right and its critics are wrong. After a short time that job will be easy, for the only critics left alive will be foreigners.

Lord Acton once remarked that "All

power corrupts, and absolute power corrupts absolutely." If the word "corrupt" is used in the narrow sense of financial corruption or corruption of personal morals, that is not always true. But power does corrupt judgment and respect for the opinions and rights of others. It removes men from the opportunity of discussing matters with their equals and causes them to be surrounded by special pleaders, sycophants and yes-men. Even when the facts can not be concealed or overlooked, power leads men to adopt the dangerous doctrine that the end justifies the means, and to do evil that good may result. And if sometimes we find that the evil they do is done to those whom they hate, and the good resulting results to their own benefit, that is only natural and comparatively unimportant.

It was a recognition of the dangers of concentrated power that caused our forefathers to set up a form of government in which the powers of government were narrowly limited and subdivided, under which the system of free enterprise was possible. Their wisdom can be tested by observation of the results attained.

One might expect that under the system of free enterprise the business men would have waxed wealthy at the expense of wage-earners and consumers in general. Such has not been the case. Competition among business men has compelled them to bid against each other for laborers, by raising money wages, and to bid against each other for customers, by lowering prices or improving quality, thus increasing the purchasing power of wages and all other kinds of income.

The last statement may be challenged, because prices have been quoted in money that has from time to time undergone sudden changes in purchasing power, either as a result of credit inflations or the debasement of the currency by politicians. But if we compare the price of an hour of common labor, or the price of a representative group of farm products, with the prices of manufactured articles over a period of years there can be no doubt that manufactured articles on the whole have fallen very greatly in price since the industrial revolution, and that that fall has been almost continuous except during great wars. Farm products have fallen by comparison with labor, but not so much as industrial products, because the necessity of using inferior or more distant soils to supply the needs of an increasing population has partly offset the improvements in farm machines and methods. Farm products therefore rose fairly steadily in price by comparison with industrial products until 1929, although they fell more rapidly during the depression. The cost of living, which is composed of both farm and industrial products, plus a large amount of services, has also fallen greatly by comparison with either hourly wages or weekly earnings. At the same time, rates of profits on invested capital and rates of interest on loaned capital have had a generally downward trend during most of the last century. These facts taken together constitute proof that the system of free enterprise has resulted not only in increasing the national income but in spreading the increase widely among the people.

There has been a good deal of criticism directed against this system, most of which stems from the teachings of Karl Marx, although many of the critics are not consciously followers of Marx. Marx's theories were evolved at a time when the free enterprise system was just getting started. They were based largely on Ricardo's iron law of wages, which economists since Ricardo have completely discarded. His illustrations of the poverty of the workers and the arduousness of their tasks were drawn from conditions of a hundred years ago. At that time, although the condition of most of

the poor was better than it had been under the older system of planned economy, it was very much worse than now. Since Marx's time inequalities between rich and poor have diminished, and all classes have become much more prosperous.

Other criticisms not directly derived from Marx's teaching are based on misunderstandings of the classical economic theory or ignorance as to conditions prevailing when that theory was formulated. There is much talk of the breakdown of competition, although competition was never more effective in its task of supplying consumers with a large variety of articles at low prices than it was in the 1920's. (When I say low prices, I mean, of course, low in comparison with consumers' incomes.) There is much talk of rigid prices, although the statistics show plainly that the prices of manufactured goods were more rigid a century ago than now. A considerable degree of rigidity is and always has been inherent in the prices of goods produced with rigid costs, and the cost of hired labor, which is the chief element in the cost of most manufactured goods, has always been rather rigid—more so in recent years because of the activities of the government and the labor unions. There is much talk of monopoly, based on the naive assumption that every large concern must be a monopoly. There is much talk about the concentration of control over industry in the hands of 200 corporations or 60 families, although the statistics when properly analyzed show no evidence of a trend toward increasing concentration of either industrial production or individual income. Even if the control of industry should become concentrated in the hands of a few hundred families or corporate groups, and even if these groups should attempt to work together, no longer competing, they would still be unable to tax or fine or imprison their customers and would-be competitors as the government can do, and they would still be subject to taxation and such other measures of government control as might be necessary to protect the public.

Since the system of free enterprise is based on the desire of each person to make as large an income for himself as possible, within the limits set by his ability, opportunity and desire to work, it follows that any line of enterprise that promises or is showing large profits will attract competing enterprises unless it is protected by law or by some natural peculiarity. There are some natural monopolies, such as the local supply of light and power and some forms of transportation, where competition would result in waste and poorer service to the public. There are also some natural resources so located and so valuable that if controlled by a monopoly the price of their products could be raised to a point that would result in excessive and undeserved profits. It is necessary also to mention that the activities of banks of deposit are so vital, and the possibilities of damage to society so great if they are not properly performed, that they have always been regulated by law to a greater extent than ordinary businesses. Cases like this are exceptional, and I think no economist would deny that they require special treatment. Whether that special treatment shall consist of government ownership, or rate regulation, or discriminatory taxation, or attempts to enforce competition, is a matter that must be decided according to the circumstances of each case. Whatever treatment is adopted will have its disadvantages, among the greatest of which will be the power it gives to politicians to favor certain groups of voters at the expense of others.

Although all competent students of economic history, including intelligent radicals, have been compelled to admit that the system of free enterprise has

greatly increased the production of wealth and the purchasing power of the common people, the public does not seem to be aware of the extent of that increase or the great contrast it makes with the history of preceding centuries.

Now it happens that there exists a record of a number of retail prices of goods and clothing, and a number of typical wage-rates as they were established by law in the reign of the Roman Emperor Diocletian. Professor Frank Abbott, of Princeton, constructed from these prices and wage-rates a table of workingmen's purchasing power in 300 A.D. for comparison with a similar table for 1909 A.D. According to his study, the purchasing power of artisans had increased about threefold in 1,600 years. But for our purpose it is more important to note that none of the improvement took place before 1800. If there were any gains in the interim they were lost, and there is no record of any such gains, although there were periods when the standard of living rose from the lowest depths for a time, especially after 1349 and after 1600.

The records of prices paid for food, clothing and fuel by hospitals and other public institutions in London, combined with daily rates of wages, show, according to my calculation, that the purchasing power of artisans in London increased 228 per cent. from 1800 to 1932. Professors Warren and Pearson calculated an increase of 680 per cent. for the same period.

Studies of the earnings of industrial laborers in the United States and the cost of living have been published by various economists. They show an increase in real wages between 1798 and 1932 of between 226 per cent. and 1220 per cent. My own estimate is 291 per cent. In other words, the average workingman can buy about four times as much with his wages as he could 140 years ago, while working only two thirds as many hours. None of these studies makes any allowance for the value of free schooling, or public health and recreation facilities not formerly available to laborers.

I have mentioned several times improvements in methods of production or quality of product. That is where the application of scientific discoveries comes in. A sound economic system must encourage the application of scientific truths to human welfare. Most present-day industrial processes would be impossible without the scientific inventions of the last century. The business men who have guided industry under the system of free enterprise have made great use of the work of scientists. They have continually experimented with new ways to satisfy the public's wants. There may, of course, be a question whether under some other system of economic organization the work of scientists might not have been utilized as much or even more. That question can not be answered by the simple experimental methods available to some branches of natural science. Economics deals with human beings, their habits, tastes and aspirations. Experiments involving human beings are costly and dangerous. Moreover, it is unusually difficult in such experiments to isolate the subjects and practically impossible to establish controls or to repeat experiments with slight variations. An important experiment affecting a whole nation, even if its failure is evident, can not be undone, and may make a return to former and better ways impossible, to say nothing of the expense and suffering it may cause.

We have been unusually fortunate in this country in having forty-eight distinct state laboratories, and many thousands of distinct industrial laboratories so that economic experiments on a small scale have been possible. It is strange indeed that the school of political thought that is most enthusiastic for the experi-

mental method in political economy is strongly committed to breaking down the walls between these laboratories, and is willing to gamble the fate of a whole nation on each new venture.

Generally speaking, however, economics must progress without the benefit of laboratory experiments except of a minor kind, and must rely on the scanty material afforded by history and contemporary international comparisons. But because the material is scanty is no reason why it should be neglected. Let us therefore examine the relation between science and the economic system in some other times and places.

Pure or abstract science has flourished under widely different forms of political organization. It requires a comfortable standard of living for the persons immediately engaged in it, and a strong enough government to protect them and their property from violent attacks, but does not require that the general standard of living shall be high. The social milieu, however, has a pervasive effect on scientific thought and even the abstractions of metaphysicians show traces of their origin.

Anarchy is inconsistent with learning. On the other hand, too much security, or, rather, too little change in the outside world, seems to be inconsistent with the development of new ideas. Under stable conditions of society learning tends to develop into pedantry and traditionalism frustrates originality. That is especially true when there is no pecuniary incentive to apply scientific principles to the ordinary affairs of life. The great advances in pure science seem to have taken place in the generations following a period in which different civilizations have come into contact, and to be a result of the impact of conflicting ideas on bright minds—for example, the development of Greek thought after the Persian wars and the conquests of Alexander, and the continuation of that development under Roman auspices until the Romans ceased their territorial expansion. That period was also marked by great commercial activity. Another period was the thirteenth century, following the crusades. Of course the fifteenth century renaissance was based partly on the transfer of Byzantine learning to the West and partly on new discoveries in Africa, America and Asia. Most of those discoveries were made by adventurers seeking for profits. Apparently the contact between different nations, languages and religions has been sufficient since then to keep the scientific current flowing almost continuously in nations of all degrees of political freedom and economic well-being. A large part of that contact has resulted from the efforts of traders and investors to make money for themselves.

It is not my intention to belittle pure science. The pursuit of knowledge for its own end may have some other justification, but whether that is so or not it seems to be essential for substantial improvements in the application of science. Some brilliant and profound thinkers are so constituted that they can work best without thought of the practical value of their work, while others with different habits of thought can only work when they see a hope of tangible reward. However, economists are naturally most interested in the applications of science, and are inclined to measure scientific progress by its results on the welfare of mankind, and must, therefore, look with disfavor on a social structure that permits the application of scientific discoveries to be delayed or devoted to undesirable ends.

Authoritarian or totalitarian states have usually permitted abstract speculation, provided it did not result in conclusions that were inconsistent with the shibboleths of the ruling caste. They have even at times permitted limited groups of scholars to hold heretical

opinions provided such opinions were not made known to the masses. Certain sciences and arts that would not conflict with the interests of the rulers were permitted and encouraged.

Mathematics, physics, astronomy, music, painting and architecture have flourished under dictatorships. But they have not been free. Everyone knows of Galileo's experience. As long as the church dominated society and was able to enforce its decrees, the shadow of Aristotle lay across the field of science, stunting growth. More recently in Germany we find achievements of science and works of art condemned and destroyed merely because of their author's race.

In a totalitarian state the possible applications of science are limited by the imaginations of the ruling class and the custodians of the sacred tradition. In a society dominated by a military caste, inventions that can be used for destructive purposes may be encouraged, although professional military men are notoriously conservative, and little original work has been done by military authorities even in the field of their special interest. Most military and naval inventions have been the work of laymen except in matters of detail. Many have met with opposition from military authorities until the stress of actual war compelled their adoption.

It is not recorded that Archimedes' speculations in physics were either aided or hindered by the tyrants of Syracuse, although they were glad to use the artillery he invented. Gunpowder was discovered in both Europe and China at a time when business was looked down upon. The Chinese, being religious rather than warlike, used it to make firecrackers for festivals; the Europeans used it for guns; only much later did private business men develop its uses for mining, roadmaking, and stump removal.

Governmental authorities are sometimes ridiculously reactionary and often they are inclined to schemes that are more spectacular than useful. These tendencies are illustrated by the immense sums of taxpayers' money spent in building barge-canals after railroads and automobiles had made them obsolete; in developing stupendous hydro-electric plants to supply markets where coal-power would be cheaper; in constructing flood-control projects so elaborate that the annual interest on the money invested is greater than the average annual loss from floods in the area to be protected; in building model villages of houses too expensive for the incomes of the persons they were intended to serve, or too far from their places of work, instead of remodeling existing structures; in teaching handicrafts whose products can not compete with machine-made goods; in subsidizing non-essential industries that can not compete with foreign products; in planting trees over large areas where lack of rain has never permitted trees to grow.

The positive acts of repression performed by authoritative states have probably not been as harmful as their removal of incentives to progress along lines beneficial to individual human beings. Restrictions on the operations of the profit motive have made it difficult to finance inventions, adopt technological improvements or produce new varieties of goods that could be sold to the people. It has been said that necessity is the mother of invention. Perhaps it would be more correct to say that ingenuity is the mother of invention. But whoever is the mother, if the invention has economic value, the business man looking for profit is usually the midwife. However, if the invention is one that is expected to aggrandize the ruling class and help suppress opposition, the totalitarian state will delegate innumerable bureaucrats to assist at the *accouchement* and claim credit for the conception as well.

The outstanding peculiarity of the sys-

tem of free enterprise has been that the initiative in both scientific work and production has been taken by individuals working for their own reasons and not at the direction of rulers or political or religious bodies. Moreover, in carrying out their projects they have been comparatively free from restrictions, except those based on public health and safety, as long as they operated honestly and without fraud or violence. The motives for activity have therefore been different from those effective in "planned" society; the human qualities required and the rewards expected have differed in degree and importance, if not in kind. These differences have extended to the common people as well as to the leaders.

The instincts or proclivities leading to business or scientific activity have been variously catalogued by writers on the subject. It is not necessary for our purposes to delve into psychoanalysis or to worry about the physiological bases of psychological phenomena or to quarrel about the definition of an instinct. All we need to consider is the effect of certain social, political and economic institutions on the operation of certain tendencies present in human beings and causing them to act as scientists or as economic men. The leading instincts directing human activity in science or business may be stated as folows:

(1) Curiosity or ratiocination.
(2) Contrivance, construction or workmanship.
(3) Emulation or imitation.
(4) Devotion, sympathy or altruism.
(5) Domination or love of power.
(6) Acquisition, accumulation, collection or ownership.

I have omitted the family instinct and the instinct of self-preservation because they are so general in their nature that they can not be said to direct men's activity into one line rather than another, except that they may tend to stifle originality in societies where everyone is expected to conform.

Recognizing that most actions are undertaken for mixed motives it is yet obvious that the first four of these instincts are especially important in connection with pure science, while the last five are especially important in connection with applied science and in connection with business enterprise. The last instinct named, that of acquisition, is not always powerful in the make-up of inventors, but there have been many inventors who were plainly under its influence. Some of the instincts in this list are also responsible for activities that can not be classified as either scientific or economic, such as the pursuit of military glory, politics, sports or religion. It should be recognized also that most men are not conscious of their motives, or even deceive themselves with regard to them. Actions based on fundamentally different motives may be outwardly similar, and actions based on essentially similar motives may be very unlike, and there is little connection between the purity of a man's motives and the social value of his actions.

All this may be freely admitted, yet it remains true that the social environment determines which instincts shall find freest expression, and especially how they shall be expressed. And it is worth while noting that the instincts that lead to business activity are similar to those that lead to the study of applied science. Consequently, an environment that encourages business activity tends to encourage the application of scientific discoveries to profitable ends.

Scientific progress has affected the economic structure of society in many ways. These, however, can be classified under four main heads: (1) Labor-saving devices; (2) transportation improvements; (3) new objects of consumption; (4) improvements in quality or lowering the price of objects of consumption already known. And in each one of these divisions not only has science affected the economic structure of society, but the

economic structure of society has limited and directed the application of science.

(1) Labor-saving devices include the elementary physical machines, the application of animal power and, above all, the application of power derived from gravity, heat or electricity. The object of these devices is to economize human labor, to enable more work to be done with a given number of workers, or the same amount of work to be done with less effort.

There was little application of power for industrial purposes under the ancient totalitarian states. Grist-mills run by water developed rather late and the uses of water power for irrigation were very limited. The principles of the steam engine were worked out by Hero of Alexandria, but it was used only as a toy or for the purpose of opening temple doors. Hero also invented a vending-machine which was used for dispensing holy water, and a combination automobile and puppet-show that was used for public entertainments. None of these inventions was widely used or had any effect in improving the condition of the people.

Hero, Archimedes and several other scholars of ancient times also invented several varieties of military machines that did come into general use. The political authorities were willing to use tools of defense or aggression; the religious authorities were willing to use devices to impress the populace; but neither group was interested in lightening the tasks of the workers or in increasing their standards of living. Totalitarian states, in fact, have always aimed at increasing the numbers of their subjects rather than their standards of living. They have wanted cannon-fodder, or its equivalent in the pre-gunpowder days, and one of the two most easily handled types of cannon-fodder is the type of man who can be persuaded that the glory of the group is worth more than the well-being of the citizen. The other is, of course, the type that is willing to exchange his life for the promise of eternal bliss in the hereafter. Both types are commoner among those who see little hope for advancement in this world through their own efforts.

(2) Cheap transportation is essential for large-scale production, and large-scale production is essential for the most efficient division of labor. But the benefits of cheap transportation resulting from scientific discoveries are nullified by tariff and similar barriers imposed by totalitarian states as part of their economic planning. It must be acknowledged that free states have also erected barriers to international trade and that such barriers have reached unprecedented heights in recent years. But autarchy or national self-sufficiency is the avowed aim of most economic planners, while it is inconsistent with the basic principles of the free enterprise system. A large part of the material progress of the last hundred years has been due to the cheapness of transportation and the consequent growth in international trade. A large part of the scientific progress of the same hundred years has been due to the greater ease of communication between scholars in distant countries. National self-sufficiency in material resources is too apt to lend to national self-sufficiency in intellectual matters. Nazi *ersatz* rubber, cotton and butter go with Nazi science and Nazi art; the Communist five-year plans go with Communist eccentricities in the teaching of history and economics.

(3) In the production of new goods scientists and those who use their discoveries are constrained to produce goods for which there is an effective demand, *i.e.*, goods that some one will pay for. Under a system of free enterprise those are mainly goods yielding direct satisfaction to individual consumers, and the greatest profits are made by producing

goods for which the demand is most widespread. Because most people, under any system of society, have small incomes it is worth while to produce goods cheaply, so that sales may be as large as possible. The people choose the comforts and luxuries which they desire, undeterred by the mutterings of moralists. And who can be a better judge of a man's wants than the man himself? Under a planned economy some person or group of persons, whether atheistic radicals or fundamentalist conservatives, determines what is good for the people, what shall be produced and how much. Even if such plans worked as contemplated, which they rarely do, they would result in depriving individual citizens of their freedom of choice. Moreover, they would put a full stop to the attempts of scientists and business men to devise new goods to satisfy new wants. Ruling classes do not want their subjects to have new wants. In other words, a planned economy would freeze the standard of living of the individual citizens at or below its present level, although it might make the state more powerful in war.

(4) By the use of new materials or new sources of power, scientists have contributed to lower the cost and improve the quality of goods already known. Here, however, a large part of the credit should go to the business man, since improvements in factory organization and administration and selling methods have been very important in reducing costs even when materials and sources of power have been unchanged. Many of the technological and administrative improvements have been of a sort that would not have been permitted by a totalitarian state, partly because of their effect on other producers who were unwilling to readjust themselves, and partly because many of them seem to cause a lessened demand for labor. Although no one has a moral right to be subsidized by the government if he continues to be inefficient after his competitors have discovered ways to market goods at less cost, or after his customers have discovered cheaper ways to satisfy their wants, it frequently happens that the inefficient groups have political influence, and if the state is accustomed to interfere in industry that influence can be used to obstruct progress. Witness the NRA, the fair-price laws, the anti-chain store legislation, etc. As for unemployment, history has shown that so-called labor-saving devices increase the demand for labor in general although they frequently have an immediate effect in decreasing the demand for certain specialized types of labor and certain individual laborers. These individuals and types often have enough influence on the government to prevent the introduction of devices that would benefit society.

The increased productivity of the human race in the last century is a direct result of the application of scientific knowledge to the affairs of every-day life. More effective use has been made of the world's natural resources. It is true that some new resources have been discovered, but they have not been so much superior to those previously known that they can explain the enormous increase in production. The mere opening up of new areas for settlement or the discovery of mineral resources similar to those already known could permit, and has permitted, an increase in population, but would not by itself increase the per capita productivity of the population.

If any one is tempted to attribute the tremendous increase in productivity and in the purchasing power of the masses in this country to the existence of a vast undeveloped frontier, he should pause and consider:

(1) That Great Britain and Sweden enjoyed similar, and almost as great, advances in standard of living, although neither had an undeveloped frontier;

(2) That Russia and Brazil with equally large undeveloped areas, did not enjoy comparable advances;
(3) That the improvement in per capita income in this country was faster after 1890 than before that year, although after 1890 the frontier had practically ceased to exist;
(4) That during the whole period from 1820 to 1930 there was a trend of migration from the rural districts to the cities, and after 1880 this trend was much more important, absolutely as well as proportionally, than the trend to the rural districts.

No, it is plain that the improving standard of living was the result of improved technology and organization, not of expanding territory or the occupation of more fertile land. And it is also plain that the improvements in technology and organization resulted not only from scientific thinking and experimenting, but also from the risk-taking of individual entrepreneurs seeking for profit.

It is not fashionable nowadays to use the kind of language Adam Smith used when he spoke of the "invisible hand." Smith wrote that the individual "generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it. By directing his industry in such manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention." Although the idea of this is essentially sound, perhaps he would have been on still sounder ground if he had merely stated that the individual frankly promoting his own welfare is no more apt to harm others than the individual ostensibly promoting the public welfare, and that it is doubtful who does the most harm to society—the hypocrite who pretends to serve the public in order to benefit himself or the pernicious altruist who pushes his panaceas down the public's throat in a determined effort to do good no matter what it costs. Against the activities of individuals in business other individuals can defend themselves. Against the activities of corrupt or ambitious politicians or of fanatical altruists in possession of the power of the state, individual citizens have no defense. Moreover, individuals in business will have little occasion or opportunity to interfere with scientific research, except occasionally to subsidize it, whereas totalitarian states must in self-defense control scientific thought, or at least its expression.

We do not need to rely on our judgment of human capacities and human motives to support these assertions. They are overwhelmingly supported by the experience of three thousand years. Adam Smith and the other early advocates of the system of natural liberty had little to offer as arguments for their belief except appeals to "natural rights" and, what was more convincing, descriptions of the universal inefficiency of planned economy, because there had been few periods in history when governments and religions had permitted individual business men and consumers to function freely, and their history was obscure. But the planned economy of his day, which was mercantilism, plainly restrained production, and the planned economy of medieval times, which was the guild system in industry and the common-field system in agriculture, had plainly failed to bring about a decent standard of living for the masses.

In ancient times the rights of the state had been regularly exalted above the rights of the individual, business had been despised and industrial labor relegated as far as possible to slaves. Many enterprises were carried on by the state through its own officials, and private enterprises were closely regulated.

The standard of living of the masses was very low. The population of Greece declined rapidly after the time of Alexander and the population of Italy after the time of Julius Caesar. Science was

mainly speculative and contributed little to increase productivity or ameliorate living conditions. After the second century A.D. there were no scientific contributions worth recording, and even technological skill deteriorated, although the Roman state maintained its power and prestige until the end of the fourth century. Perhaps the degenerate Romans were unfit for any form of government but despotism. Perhaps on the other hand despotism made them unfit.

The failure of planned economy in ancient, medieval and early modern times was apparent. The attempt to impose it on the American colonies stirred up so much opposition as to result in the Declaration of Independence, and the establishment of a nation based on individual liberty and free enterprise.

Perhaps some friend of governmental economic planning may assert that its failures in the past have been caused by the stupidity or lack of training of the officials in charge of it. But no scientist seriously maintains that the human race is any less stupid now than in the days of ancient Greece and Rome. Aristotle and Euclid and Ptolemy were doubtless as intelligent as Newton and Einstein. Pericles and Caesar and Marcus Aurelius were doubtless as intelligent as any present day ruler. The bureaucrats of the Roman Empire were carefully trained in universities and law schools, and had a high *esprit de corps*. The bureaucrats who worked for the "enlightened despots" of the eighteenth century were likewise trained in universities, and the science of statistics was invented to help them in their work. But even in those days, when the contrast between the educated rulers and the uneducated masses was greater than now, it proved to be true that most men could manage their own businesses better than others could do it for them.

We are more fortunate than Adam Smith. We have, to help our judgment, not only the horrible examples of planned economy that he had, but new varieties such as Communism, Fascism, Naziism and various aspects of the New Deal. We also have the amazing record of achievement under the comparatively free system prevailing in the United States, Great Britain, and some other European states in the nineteenth and early twentieth centuries. Even with the example of these countries before them, countries like China and Russia with vast areas and variegated resources were unable to equal the achievements of the free nations, because they were not free. Despotism in the one, and ancestor-worship in the other, were able to block progress. If national planning had been a fit instrument for effecting national progress, the highly centralized government of Russia and the highly trained civil service of China should have been able to raise their nations' standards of living at a rate comparable with that attained by the free nations of the West.

History thus shows that when power over the economic affairs of a nation is concentrated, industrial progress slows down and ultimately ceases. At the same time scientific progress in general slows down or is directed into lines approved by the authorities, where the efforts of scholars are either futile or destructive. The officials who proclaim themselves guardians of the interests of the people refuse to permit the people to decide their own interests and their own preferences, and to attempt to satisfy one another's needs and desires.

By contrast, the system of free enterprise is based on the principle that each man shall decide for himself how he wishes to spend his income, and that any one who wishes to offer his wares to the public, for them to choose among, may do so. The consumer votes every time he

spends a cent or a dollar what shall be produced and who shall produce it. The various producers and would-be producers have no power of compulsion over their customers; they must rely on persuasion, not force. They have no authority to suppress rival producers or to suppress criticism of their wares, and most important of all they can not prevent improvements in products and in processes. By the same token they can not prevent scientific progress. In fact they must encourage it, for the best way to get customers away from other producers is to make a better product, or a cheaper one or a more acceptable substitute. Under this system science and human welfare have made enormous strides.

Consequently, any one who desires that the progress of science shall continue must oppose the current tendencies to government regimentation. He must oppose the direct regimentation of science and likewise the regimentation of business, both because the regimentation of business inevitably lends to the regimentation of science, and because the regimentation of business would reduce the demand for scientific discoveries and retard the beneficial utilization of such discoveries as might be made.

We have had a taste of freedom in this country and Western Europe during the last century and a half. The taste has been good and its effects beneficial. We are now offered a draught that on analysis reacts like the water that our ancestors drank from the bitter well of despotism. It has been sweetened and colored to look different, but in concentrated doses it has brought great suffering to our friends in Russia, Germany, and Italy, and the few drops that we have imbibed have already had a debilitating effect on us. To take more now would indicate that we are unable to learn by experience; and I think that the readers of this MONTHLY will agree that he who is unable to learn from experience is not worthy of the name of scientist.

SERIOUS DAYS

THREE days ago a substantial proportion of both the student body and the faculty of Haverford College were registered on this campus for what the Selective Training and Service Act calls "work of national importance." I had thought that the faculty at least were already doing work which deserved to be so characterized, but perhaps not.

The long arm of the state, reaching out to this tranquil, self-governing community, has thus given us a reminder of its pervasive and inexorable power. For the moment it is only a reminder, but even so this registration must be regarded as a portent of the new and difficult age we are entering. All too clearly it foreshadows the unwelcome but inescapable problems which loom ahead for this and educational institutions of similar character. If we are to save our privately endowed colleges we must give close attention to the way the tides are running.

A bitter paradox underlies many aspects of our era. The marvelous achievements of science are being used to destroy the civilization which science has achieved. Learning has been directed to the obliteration of its own temples. The great ideals of human liberty are led to the sacrifice by those who would preserve them. But of all the paradoxes around us none is more disconcerting than the fact that we, living during one of the greatest upheavals of recorded history, have so little understanding of the historical significance of our own times.

For some this lack of insight need not be disturbing. The physician, for instance, is fulfilling his social function if he faithfully follows his mission of healing. The architects who design, and the engineers who execute, can rest with an easy conscience at the close of each day's construction. Even the newspaper man, though frequently devoid of both rest and conscience, may preserve self-respect by adequately presenting and inadequately analyzing the day's events as they develop. But for the educators, at least for those who are not merely vegetators, the times are fraught with a peculiar tribulation.—*Inaugural address of Dr. Felix Morley as president of Haverford College.*

FOOD SUPPLY OF CONTINENTAL EUROPE

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CONTINENTAL Europe is under blockades which hinder importation of foodstuffs. The British blockade is on the surface of the sea; the Axis blockade is under the surface. Europe also faces a pseudo-blockade by Russia. Under these circumstances, the population of Continental Europe must expect to subsist through the winter on the inbound carry-overs from last year and the yields of the 1940 crop. It is important at the outset to define area and population of "Continental Europe" in this article.

Continental Europe is the area west of Greater Russia, north of the Mediterranean, east of the Atlantic Ocean, and south of the Polar Sea, but not including the United Kingdom. In Soviet Russia are now included Finland, Estonia, Latvia, Lithuania and Bessarabia. The United Kingdom stands apart, because it has open sea-ways to the overseas sources of supply, which the blockades exclude from access to the Continent.

There are but two countries north of the Alps still neutral and not under the control of Germany—Sweden and Switzerland. It is to be inferred that Sweden, Portugal, Spain and perhaps Switzerland, will import, under British permits, stipulated amounts of foodstuffs.

Including adjustments for recent boundary changes, the population of Continental Europe, as herein defined, is probably in the neighborhood of 310–320 millions. The question before these countries is whether they can be nourished on the European food supplies, without development of (*a*) obvious but not serious, (*b*) moderately significant or (*c*) severe reactions of famine upon public health, including incidence of disease and death rate. The matter is not made simpler by suggestion that food habits be changed as supplies dwindle—that population is to turn towards vegetarianism, and plant foods not now regarded as edible are to be used as stretching substances. Europe has not forgotten the "winter of turnips," the use of bulrushes in bread, of beech buds in soup, etc. There is no quantitative definition or numerical measurement of famine in the early stage of food shortage, since effects are irregularly cumulative, as illustrated in various countries in Europe during the years 1916–1925. An arithmetic average may be most misleading. Whenever a significant food shortage occurs, individuals are certain to suffer; the question is the number, sex and age, and location in place and in income class.

The food supply is a bundle of edibles. The important groups in the food supply of Continental Europe may be grouped under:

(1) bread grains,
(2) fodder grains,
(3) oil seeds and their products,
(4) sea-food.

I. Small grains grow well over most parts of Europe and laterly selections have improved yields. Oats are raised in the northern areas, where other grains do less well; rye is raised in cold climate and with poorer soils. Wheat is grown in nearly all countries, corn more or less everywhere south of the latitude of the Alps. Since the World War, the growing of wheat has been significantly expanded geographically (by selection and use of appropriate

methods) so that the acreage now regarded as normal is perhaps ten million acres more than before the World War. This increase in acreage (with selection of better varieties and application of fertilizer) has resulted in significant increase of the potential wheat crop. Thus, good or average crops of wheat secured in the thirties exceed the crops of the twenties by several hundred million bushels. The improvement in crop of rye has been less.

The importation of wheat has declined during the last decade, more or less as result of increase in crops of bread grains. Thus, the "Continent of Europe" in a fair crop year in the twenties imported more than 400 million bushels, whereas in a good crop year in the thirties, less than 200 million bushels were imported. This indicates, comparative advantage aside, that economic nationalism produced results in crops. But no one in the Axis powers, or in the surrounding countries subject to them, pretends that enlarged wheat production in the net-importing countries could be further expanded to cover needs, though in an occasional year a bumper crop might nearly do so.

There are four wheat net-surplus countries in the Danubian region—Hungary, Yugoslavia, Roumania and Bulgaria. These have been competitors of Russia and overseas wheat-surplus countries in supplying wheat. But even under favorable conditions they could not be expected to take over the total burden of supply of wheat to the Continent of Europe; certainly under present conditions of disorganization, no such prospect is conceivable. Therefore, with normal bread-grain crops, it follows that in the forseeable future the Continental food supply would be short to the extent of bread-grains previously imported from overseas. And, these may be taken roughly as 160–200 million bushels in recent years.

The crop of 1940, however, was not a large wheat crop like those of '39 and '38, not even a "normal" wheat crop; it was probably the smallest wheat crop in a decade, and one of the smallest wheat crops since 1920. Crop shortage was due to severe winter-killing, heavy floods in the spring, and disturbances by war in Poland, Holland and Belgium. Using the published estimates of the U.S.D.A., with trade estimates in different countries of Europe, it would seem necessary for "Continental Europe" to regard the available supply of new wheat at less than 1,300 million bushels and of rye as less than 800 million bushels, together less than 2,100 million bushels of bread-grain, to be raised or lowered when more accurate estimates are available. The gross figure includes grain for seed and also for feeding to animals. The inbound carry-over of bread-grain is supposed to have been in excess of previous years, due to occurrence of successive good crops and to storage for war.

The implication of the crop, however, is not as high as the figure. Whenever war occurs, peasants tend to hoard grains and hide animals—a normal psychological behavior in peasants. Such withdrawal is made more active if price, trade and transportation are abnormal or unsatisfactory. Seizure of grain by police may be easy when it can be readily moved, but becomes difficult when this is not the case, which applies to the present conditions in the Danubian countries. Also, where peasants have been compelled to accept goods instead of money, antagonism has been aroused. Fluidity of movement of grain has been lowered in the Danubian states during recent years and requisition is difficult, except where a terroristic government is strong enough to override local resistance.

The larger the proportion of imports needed to meet requirements, the more

difficult becomes distribution from outside. It, therefore, seems inevitable that with continuation of blockade, with a short bread-grain crop and with disturbing difficulties in transportation between states and within states, the bread available through ration or through allotment of flour, is sure to be more or less heavily reduced. Europeans are heavy eaters of bread (over 5 bushels of wheat and about half as much rye per capita is the continental need); shortage is at once felt unless the lacking calories can be replaced with potatoes, sugars, fats and vegetables.

Ordinarily speaking, in the case of bread there is not as much concentration of effect of shortage on low-income classes as in the case of shortage in fats, meats or dairy products. The bread grains are calory foods, and have their major importance in maintenance of body weight and manual work. Thus, shortage of bread grains is less injurious than shortage of dairy products and fats of comparable extent. When the supply runs short, the first effect is loss of body weight, which may be slight or extend to emaciation if long continued.

II. Europe has gradually become more and more dependent on imported fodder grains. These include corn, oats, barley and rye; even the imported bread-grains contribute to feeding stuffs to the extent of nearly 30 per cent. To these must be added the oil seeds (meal and cake) which are imported. The primary purpose of import of such grains and oil seeds is to supply protein, the carbohydrate being secured from pasture. The extent to which the imported protein contributes to edible animal products is impossible of computation, but it is heavy in many countries. It is, of course, to be kept in mind that the proportion of meat contributed by imported feeding stuffs is more than is the proportion of imported feeding stuffs related to domestic feeding stuffs, since the maintenance of the breeding herd of younger animals must first be maintained, while imported feeding stuffs are applied mostly in finishing stock for the market.

Certain adaptation is possible, which was practiced by Germany during the World War. Hogs are much more efficient converters of feeding stuffs than cattle; if heavy slaughter of cattle is accompanied by heavy breeding of hogs, a significantly larger supply of meat is secured from a stated supply of feeds. This, however, runs against the views of peasants, requiring arbitrary control and extensive policing of farm products. Any lowering of import of concentrated fodders or shifting from cattle to hogs also disturbs export trade in animal products—very important in Western Europe—and this provokes resistance. The blockades on concentrated feeding stuffs into Western Europe hit Britain hardest, since that country was the heaviest importer of meats and fats from across the Channel and North Sea.

III. The fat and oil supply is the Achilles heel of the European food supply. Soil and climate of Europe are less favorable to cultivate of oil seeds than of grains; therefore, Europe has developed dependence upon direct and indirect importations of oils and fats. Direct importations include coconut, palm, palm kernel, cottonseed, peanut, flax, soybean (and others) as seeds and also as expressed fats. Included further are large amounts of animal fats—lard, tallow, whale oil and other marine fats, and even butter. Indirect importation of fat is secured through farm animals fed on imported feeding stuffs, animals which could not be sustained on domestic feeding stuffs. A number of countries in Western Europe are veritable feeding yards, in which local grasses and imported grains and oil seed concentrates maintain animals upon the artificial scale promoted. As a con-

crete illustration, as soon as Germany took possession of Denmark, Holland and Belgium, their feeding yards had to be curtailed; following reduction of number of animals to the level of feed supply unaided by imports, the outturn of meat and fat will be heavily reduced. The sum of indirect and direct contributions of imports is large in Western Europe.

Fat, however, has other uses than as food, namely, in soaps and explosives, bringing about the "choice between guns and butter," as Goering is supposed to have expressed it. It is possible separately to synthesize glycerine needed for explosives and fatty acids needed for soaps; but developments have not extended to the scope necessary to replace the lacking importations. The extent to which food fats are diverted to propellants in belligerent countries is not known, but the defection is surely significant.

Heavy reduction of import of concentrated feeding stuffs, leading to shortening of the milk supply, is certain to create problems in child health—since milk supplies minerals, balanced protein and vitamin A, which can hardly be replaced when there is shortage in other directions in the food supply. Western European countries have used feed imports both to produce butter from cows and margarin from factories; heavy reduction in such imports will have the double effect of cutting down the milk supply, with its nutritional virtues, and the fat supply, with its industrial utilities.

The effect of shortage of fat upon food supply is not merely one of calories, it is also one of taste. The Germans used to think that sauerkraut was a cabbage dish, but during the World War they discovered that it was eaten more for the fat added to it than for the cabbage. In Europe more than in the United States, fat is the important component in the art of cooking; much of the traditional characteristics of mixed dishes of pastes, meats and vegetables were derived from fats. The lack of fat is a heavy loss in calories, used for the support of body heat and work; unless made good by carbohydrates, the result is sure to be felt in loss of body weight and in working strength. Europe is supposed to have this year a better-than-average crop of potatoes and a good crop of sugar beets, which to some extent are counted on to take the place of fats. Also, there will be an excessive killing of farm animals prior to the first of January (imposed by lack of imported feeding stuffs), which for the time being will serve to replace the shortage of imported fats. The real fat shortage, therefore, is not to be anticipated until after the beginning of the new year.

IV. Fishing has been a prominent food industry in Europe. From the northern tip of Norway to the Gibraltar, fishing fleets operated as far west as Iceland, Newfoundland and down even into the Antilles. Important also has been fishing in the Mediterranean and in the Black and Caspian Seas. Since the World War there has been an extraordinary expansion in whaling, and the contributions of Antarctic whaling to the European fat supply have been surprisingly heavy.

The stress laid upon sea food earlier in the diet in Europe was based largely upon the use of fish as substitute for meat. At present, however, the importance is recognized to be more significant in a different direction, namely in the contributions of iodine and vitamins A and D. These two fat-soluble vitamins are located more or less throughout the bodies of fish, but particularly are concentrated in the liver, and are rather scarce in most foodstuffs. The inability of fishing fleets to operate in the company of mines, submarines and airplanes inflicts upon the population of Europe a

slightly significant loss of protein and calories, but a highly significant loss of fat-soluble vitamins. Lacking vitamin A and D from sea food, the otherwise European diet could hardly provide vitamins A and D to cover minimal needs, and widespread deficiencies will arise, particularly in the poorer classes. When in the World War, the interior inhabitants—for example, in Austria—were deprived of sea foods and cod liver oil, rickets became common and severe. Under comparable circumstances, deficiencies in vitamins A and D will occur again, largely in the poorer classes, in severity dependent upon other factors. It is perhaps a significant commentary on the situation to say that at present fish liver oils are being shipped from the Pacific Coast to Great Britain, in order to replace the extinguished supply from the North Sea and North Atlantic.

It is, of course, true that vitamin A from fish supply is only one supplementary source of vitamin A; but it is a very important one, particularly in certain regions. Vitamin A enters the diet in milk and in many fruits and vegetables. The history of Northern Europe makes it clear that if vitamin A from fish and milk are both scarce, then vitamin A from plants can not be relied upon to cover needs.

The present art of the chemist does not insure commercial synthesis of vitamins A and D. In the presence of adequate sunshine, vitamin D is dispensable in the diet; but Europe north of the Alps does not have sufficient ultraviolet light to prevent rickets. Therefore—on the basis of experience in northern Europe over the last hundred years, and particularly the experience during the World War and since—an increased occurrence of deficiency diseases due to shortage of vitamins A and D is to be expected, more or less widespread in different countries north of the latitude of the Alps and occurring especially in the lower-income classes.

V. The food shortage connected with the World War was in three periods, differing in cause, incidence and effect—namely, food shortage during hostilities, during the Armistice and during reconstruction after reestablishment of peace, which lasted in most countries until 1924. European countries are now in better statistical position to appraise their situations than then; also, the newer knowledge of nutrition will aid in guiding remedial measures.

Each country will attempt to stretch the food supply by rationing. The hungry can not subsist on averages; it is possible for a fifth of a population to suffer health-devastating shortage, while the four fifths manage to get along. A ration, more or less in different countries, has four purposes. The first is to prevent the rural districts from using more than the share belonging to them. The second is to provide equity between income classes. The third is to make special allocation of protective foods, especially to children. The fourth is to provide added calories for hard-working adults. A ration may be carried out with free prices, with controlled maximum prices or with fixed prices under state subsidies. The latter plan alone seems capable of providing effectively for the second and third purposes of rationing. The older technique of rationing was thoroughly learned during the World War and is easily revived in all countries. Germany had indirect rationing of certain foodstuffs, such as fats, for a number of years before the present war. But state subsidies, where necessary, may not be easily obtained under present conditions of taxes and currencies. Since all countries in Europe (even the Danubian states) will need to ration, this will make rationing everywhere more diffi-

cult. Particular problems will arise in those countries where agriculture and food supply have been more or less based on imports. Geographically, the more acute problems will arise in the western fringe, beginning with Norway and extending through Denmark, Holland, Belgium and France (with the problem in unoccupied France perhaps even more difficult than in occupied France), since these heavily deficient countries are not in position to barter with the Danubian states. In most countries, a special problem is the feeding of refugees. In the meantime every country in Europe will make strenuous efforts to expand acreage and raise yields in the crop of 1941.

It is important to understand that the food blockades of the two belligerents differ in derivation and in application, but not in fact or effect. In the older literature on blockades is to be found segregation of contraband and non-contraband, then division of contraband into conditional and absolute contraband. In modern war, all articles are contraband, more or less, in use or substitution. There is no separation of civilian from belligerent, only a gradual transition, overlapping of home-front and fighting-front. Britain blockades the Continent of Europe to close all channels to the Axis Powers. The Axis blockade prevents ships from entering Western Europe or Mediterranean countries by sinking without warning. The British take blockade-runners into prize-court, the Germans take them to the bottom of the sea. The practical effect of these blockades is to prevent the countries of Continental Europe from importing foodstuffs from overseas. There is no practical purpose in trying to invoke traditional "legality" or inherent "morality" in interpretation of food blockades. In the modern war—mechanized warfare—all units of population have become participants. Goods and services are one and indivisible.

The word "famine" derives from folklore, not from science, and is arbitrarily used. When the monsoon fails, then follows "famine"; when a city is besieged, the lack of food is called "famine." But when lack of food causes beriberi in the Orient, pellagra in the Balkans, scurvy in Mesopotamia, or zerophthalmia in Denmark, this is not called "famine." Thus, in folklore occurrences of "famine" and "starvation" depend upon forms of deprivation. Dynamically defined, we ought to regard as famine any shortage of food which significantly fails (a) to sustain normal activities, (b) to maintain normal growth and weight, (c) to sustain normal resistance to infectious diseases, and (d) to prevent occurrence of deficiency diseases. Thus famine ought to include a deprivation of particular foodstuffs, as well as general scarcity of food,—and may be mild, moderate, severe or fatal. In this sense should famine and starvation in Europe be judged. In this sense famine has always existed in Europe, in spots and involving small numbers. In war, it is to be expected that famine will expand to cover wider areas and involve larger numbers.

BOOKS ON SCIENCE FOR LAYMEN

HAS THE UNIVERSE A SOUL?[1]

In this interesting book the author attacks an extremely exciting and important problem concerning the applicability of the principles and methods of modern physical theory to the phenomena from the field of biology.

The book begins with a very clear presentation of the fundamental ideas of the relativity and quantum theories, with particular emphasis on the existing *dualism* between the *particles* as the essence of matter, and the *fields* as the "immaterial" (*i.e.*, deprived of mass) leading agents directing the motion of these particles.

The following chapters describe the fundamental biological facts pertaining to the structure, fertilization and division of living cells, and the development of organisms. The rest of the book (about one half) is devoted to the author's own theory in which he tries to describe biological phenomena in a way analogous to the quantum-mechanical description of the atomic phenomena in modern physics. From here on, the reader trained in theoretical physics could not help but wonder. Already in the purely physical part of the book, the author makes an assertion which, though very helpful in building biological analogies, essentially deviates from the ideas accepted in physics. He speaks about the wave-function describing the motion of particles in an atom, as about something existing in the three-dimensional space and possessing certain "objective reality" in spite of the absence of mass ("immateriality"). It is well known, however, that wave-functions describing the motion of mechanical systems could be represented geometrically only in imaginary multi-dimensional spaces, and thus possess no physical reality in ordinary space. Being evidently aware of this objection, the author tries to remove it by saying (footnote on p. 50) that "this is due to the fact that in our observations we can not distinguish one electron from another." This remark is, however, evidently based on some mistake because also in the case of quite different particles (as proton and electron in the hydrogen atom) the wave-function can not be represented, strictly speaking, as a function of only three coordinates. The only case when the three-dimensional presentation of the wave-function of a system is possible is the case when the separate particles do not interact at all with one another. In this case the multi-dimensional wave-function splits into three-dimensional components in the same way as the three-dimensional motion of a particle in classical mechanics can be split into three one-dimensional motions if the potential energy is the product of three independent functions (separation of variables).

This erroneous assertion brings the author, in the way of analogy, to the introduction of "immaterial living wave functions," or "genii," existing in three-dimensional space and leading the motion of different parts of living cells "in the same way as wave-functions of quantum theory lead the motion of electrons in an atom." Besides the above-mentioned fact that the analogy here is missing, it is quite unclear why the author uses the prefix "wave." In quantum theory the introduction of wave-functions became necessary after it was found that the electron-beams show the characteristic phenomenon of diffraction which could not be described in the language of particles. Since in the field of biology no phenomenon analogous to diffraction of light or electron-beams has been as yet discovered, the

[1] *The Soul of the Universe.* By Gustaf Strömberg. xviii + 244 pp. $2.00. 1940. McKay.

prefix "wave" is quite misleading and serves only to stress the non-existing analogy with the phenomena of quantum-physics.

It is still less clear why such dualism should be introduced at all in the description of biological phenomena. The dualism in physics was the result of the discovery that the motion of particles possesses certain wave-characteristics which could not be united with the particle characteristics in one simple mathematical scheme. The wave- and particle-aspects in physics reveal different sides of the motion, and are in this sense *complementary*. The "living wave-functions" introduced by the author do not possess this property of complementarity, and simply repeat everything that the material cell does. The "genii" grow, divide, etc., when the cell goes through the same stages, and this doubling of the process does not explain anything. The tautology resulting from the introduction of the word "genie" is broken only by the author's assertion that "the genii can exist and retain their properties, even when they are not associated with matter," which he finds necessary to explain the eternity and transmigration of souls. But here the analogy with the quantum-mechanical wave-function entirely breaks down!

Concluding, one must say that whether these "genii" really exist or not, *they certainly do not represent the slightest analogy with any notion used in modern physics.* Apart from the badly fitting disguise-dress of physical terminology, these "living wave-functions" are practically identical with the centuries-old ideas of soul, spirit or the mysterious "élan vital" of the old biology.

G. Gamow

LO, THE POOR INDIAN![1]

The curator of anthropology of the American Museum appeals in this work to a wider, and less serious, audience than in his "American Indian." There are two ways of giving readers of this class a "taste" of the subject. Either matter may be abstracted and highly condensed in an attempt to cover the whole field, or the field may be sampled in a few select studies appealing more largely to the imagination and the emotions, and sometimes in fictional form. Dr. Wissler has chosen the first method and has brought the high-lights of his subject before the reader exceedingly well, but his style suffers from the intense compression to which the material has been subjected, especially in Part II. Part I is a brief review of "The Indian in Prehistoric America," Part II a consideration of "The Great Indian Families" and Part III a discussion of "Indian Life in General." There is a page of suggestions for further reading and an appendix of six pages answering questions regarding the Indian which Mr. Average Man is most likely to ask.

Whoever attempts a general work of this character inevitably exposes himself to scalping parties of specialists, and they will not have much difficulty in finding opportunities to count coup in the present instance. Dr. Wissler's classifications are evidently intended to take in as large areas as possible and that may explain the unexpected allocation of some of the tribes. If Salishan tribes are to be classed as "possible members" of the Algonkin family the Wakashans should also. The Tobacco Nation should have been added to the list of independent Iroquoian tribes, and the Missouri —having given their name to a state— should have been added to the Siouans. One's breath is somewhat taken away by the extension of the Penutian family, and, if we remember rightly, Sapir placed the Tsimshian in this group rather than with the Na-Déné. The author is at least up to date in listing the Mayans under the Uto-Aztecans. The arrangement of the Caddoan tribes, however,

[1] *Indians of the United States.* By C. Wissler. Illustrated. xvi + 319 pp. $3.75. 1939. Doubleday, Doran and Company.

certainly needs revision. Caddo is the most aberrant dialect and should stand by itself. Wichita and Kichai should be coordinated with Pawnee and Arikara, and Tawakoni and Waco be placed under Wichita.

Unfortunately, there are blunders of a more regretable character. For instance, Kentucky does not mean "the dark and bloody ground" (74), the Sheyenne River of North Dakota has been confounded with the Cheyenne River of South Dakota (92), Ojibway and Chippewa are two forms of the same word and belong to one people (97–8), the "original Algonkin" were in the western part of the Province of Quebec and distinct from the Ojibway, Menomini and Potawatomi (99), the Huron were not identical with the Tobacco Nation nor the Neutral Nation with the Erie (113–4), the Tunica Indians were allies of the French and not annihilated by them (147); in speaking twice of "the boundary between Mississippi and Georgia," Dr. Wissler has crowded Alabama off the map (148–9), the Caddo did not "hold the river front" on the lower Mississippi in historic times, not in fact extending east of the Ouachita (155); Minnesota signifies "clear water," or water having a slightly milky appearance, not "waters many" (158), Canada became British territory in 1763, or 1760 if the conquest date is desired, not in 1754 (164), the survivors of the eastern Siouans are found in South Carolina, not on the lower Mississippi (178), and by "late in 1600," "early in 1700," and "early in 1800" we are evidently to understand the seventeenth, eighteenth and nineteenth centuries, respectively.

Part III is by far the best section, but, as a center of population density, Florida should not be excluded from company with the other southern states (239), maize certainly could have sustained many eastern tribes for "a part of the year" if not sometimes for an entire year (241), part of the agricultural work in the Southeast was done by men, not all by women (242), it would be nearer to the truth to say that white men rarely understood Indians than to say that they "never" did (270), the black drink was not a narcotic (296), and many will hesitate to categorize "head shrinking" among the "important inventions" (295).

The answers to queries are generally excellent, but a few emendations are called for. Shell money was, of course, used on the Pacific coast, but there it should not be called wampum (303–4). In fact, wampum was originally confined to the neighborhood of Long Island Sound. In the Southeast men and women danced in some dances together though not after our fashion (304). The Great Chief of the Natchez possessed something like arbitrary power and so did many of the heads of leading families on the north Pacific coast (305). Mulberry bark was more important than nettle fiber as raw material for textiles in the Southeast (306).

We are conscious of too many glass windows of our own to enjoy throwing stones, but it really seems as if a little more editorial care might have eliminated most of these slips, and there is no reason why a second edition should not make this a noteworthy publication.

John R. Swanton

TWINS AND SUPERTWINS[1]

The criticism has frequently been made that scientists have been remiss in making known their discoveries to the public at large. The book "Multiple Human Births" is a direct refutation of this accusation, for not only does the

[1] *Multiple Human Births.* By H. H. Newman. Illustrated. xv + 214 pp. $2.50. 1940. Doubleday, Doran and Company, Inc.

author give a clear and readable account of the work done in trying to solve the various questions which arise in connection with the study of twins but even further this is the first of a series of popular accounts of scientific work to be published by the American Association for the Advancement of Science. The choice of the topic is a happy one, for every one is interested in twins and many advances in our knowledge have come as a direct result of investigations on them. Here nature has set up for us an experiment and in the one-egg twins has provided two individuals with the same heredity. In such cases the effects of varying environments can be studied. Many workers in many parts of the world have investigated different angles of the problems involved. For the first time their work has been summarized and put into such a form that any one can know what has been done. Dr. Newman has been very fortunate in presenting his subject so that it will be readable and easily understood without making it too simple.

When one thinks of twins many questions come to mind. How are twins formed? What about triplets, quadruplets and quintuplets? How many kinds of twins are there? Do twins run in families? How much alike are twins? Why? What can be learned from twins about human heredity in general? What has been learned from the study of the Dionne quintuplets? All these and many other questions are raised, discussed and answered in this book. The embryologist, the geneticist, the psychologist and the sociologist will find the material presented useful and worth while. The lay reader will here find a real adventure in store. For those who wish to continue the study a good bibliography is included. To quote, these "researches have shown conclusively that the human heredity-environment problem is extremely complex, that it is not one problem but many, that the problem differs with respect to every character studied and there is therefore no general solution for the problem as a whole. . . . There remains much to be done."

D. B. YOUNG

MEN AND GLANDS[1]

A SUBTITLE qualifies the book as "An Introduction to Constitutional Psychology." It could have more fittingly, perhaps, been called "a highly involved treatise on the effects on the human body and mind of glandular and other pathology."

The volume impresses one strongly as a large but vain effort to sustain and advance a line of theories of not even indigenous origin; theories which, except in a few points, find no confirmation in biology, or normal anthropology, anatomy and physiology. The authors fail to see that they are dealing with all sorts and grades of aberrations from the normal; that their classifications at one time of the life often change in the same individuals as they grow older; that these classifications fail with people of other races; and that even in Whites, at a given time, there are innumerable transitional cases and uncertainties that will baffle even the best judgment. Unfortunately, fallacies are stronger than reason, and serious critical work and travels are hard and untasteful.

There is an over-extensive index, many parts of which are quite useless, while others (p. 328) are displaced. It is strange that the publishers, with their great experience, have passed such an index.

ALEŠ HRDLIČKA

[1] *The Varieties of Human Physique.* By W. H. Sheldon. Illustrated. vii + 347 pp. $4.50. 1940. Harper and Brothers.

THE PROGRESS OF SCIENCE

GEOFFREY CHAUCER, 1340?–1400

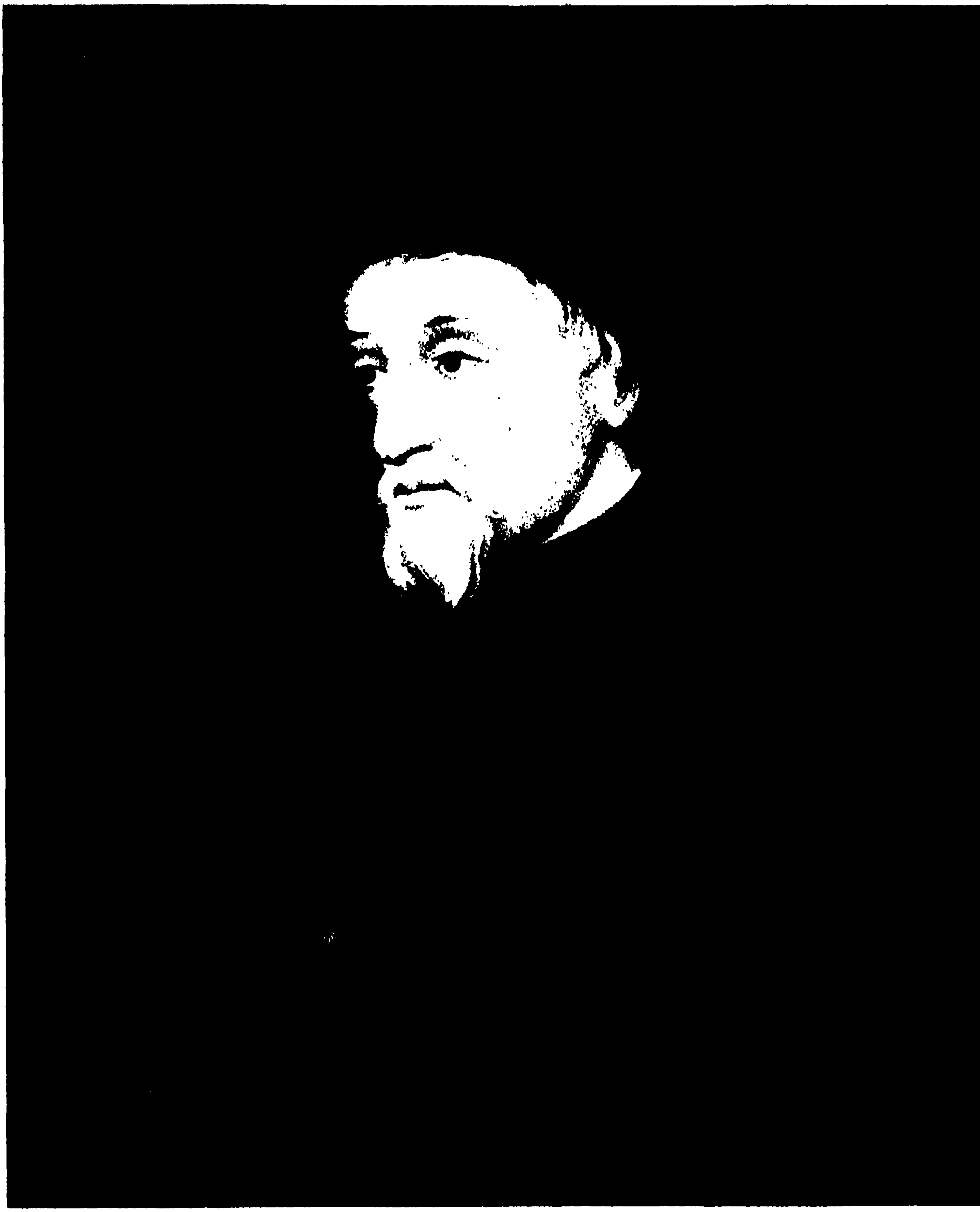
Born six hundred years ago and still alive! How few are the poets of which this can be said! Fewer yet are those who, having come so early, have worn so well. Chaucer is not a classic read merely out of respect to a reputation in the past; he is read as a present source of delight and joy. The oldest of the major English poets, the first of the royal line, he is in some ways the most modern. And his germinating power is still vital. The Poet Laureate to-day is a disciple of Chaucer and has said that when first he turned to the making of poetry, it was in Chaucer that he found the kind of thing he most wanted to do.

Chaucer's life was a varied and busy one, quite apart from literature. As soldier, courtier and man of affairs, he spent most of it, from youth up, in fairly close touch with the court circle. Page to the Countess Elizabeth, squire in the king's household, controller of customs, emissary and diplomatist of two kings on seven or eight missions abroad, sometime Justice of the Peace, Member of Parliament, Clerk of the Works, Sub-forester of the King's Forest, etc., etc., Chaucer is the triumphant refutation, once for all, of the popular notion that poets are a long-haired, dreamy-eyed fraternity incapable of attending to practical affairs and a little insane.

Among other things, Chaucer was a man of learning, widely read in several fields besides literature. He was not what we should call a scientist, but his knowledge of science, or of what passed for science in his day, was great. His "Treatise on the Astrolabe" is a scientific work. His poetical writings are studded with references to astronomy and astrology. In various passages he shows detailed knowledge of the theory and practise of medicine in his day, and in the "Canon's Yeoman's Tale" intimate acquaintance with the terms and practises of alchemy. In the "House of Fame" he gives an account of the theory of the transmission of sound which will pass muster to-day. And in dealing with dreams and the problem of foreknowledge and free will, he shows that he is versed in philosophy, metaphysics, theology and what is now psychology. Something of the scientist is seen, too, in Chaucer's love of facts. No poet since Homer has had a keener eye for facts, for solid, concrete facts; nor is there any whose work is more firmly based on fact. The Prologue of the "Canterbury Tales," for example, owes its success to Chaucer's brilliant command of facts and power of using them artistically.

To speak of Chaucer as poet is to seem to exaggerate; one must use so many superlatives and claim so many "firsts." The founder of the great tradition in English poetry, all subsequent English literature is enormously indebted to him. He is the greatest of narrative poets, and among his works are discovered the first examples of the modern novel and the short-story. He is the first realist in English literature, the first humorist, the first master of character portrayal, the first great exponent of life-like dialogue. In these respects he is not only the first but one of the best.

No better specimens of the fabliau are to be found anywhere than the tales of the Miller, the Reeve, the Merchant and the Summoner. The "Nun's Priest's Tale," besides being a perfect fable, is a mock-heroic poem unexcelled even by Pope's "Rape of the Lock." The "Man of Law's Tale" and the "Clerk's Tale" are among the noblest examples of pathos



GEOFFREY CHAUCER

FROM A LIMNING IN OCCLEVE'S POEMS IN THE BRITISH MUSEUM. ENGRAVED BY J. THOMSON.

in our literature. And "Troilus and Criseyde" is not only the first novel of character and one of the world's great love stories, but one of the triumphant examples of sustained narrative in all literature, as great in design, in handling of plot, character and background, as in the beauty and finish of its poetry. Finally, Chaucer is the first great English prosodist, whose verse has never been surpassed in ease, simplicity and unfailing melody.

It is a common error to think of Chaucer as the poet only of the "Canterbury Tales," as above all a realist and satirist, who tells bawdy stories, delights in calling a spade a spade, and makes mention of such things as the "stinking" breath of the Cook and the hearty sweating of the Canon's Yeoman. This is the vulgar notion, and the vulgar connotation of the word *Chaucerian.* Of course, there *are* these things in Chaucer, but only because he knows men and women so thoroughly and in such variety, and as an artist with nothing less than a balanced realism which paints characters in the round. So far from being only or chiefly a realist and satirist, he is fundamentally and chiefly a poet of love. As a poet of love he is a poet of nature—of the May morning and the daisied fields—and a poet of beauty, grace and sentiment; of all, in a word, that came from and with the poetry of courtly love in France and Italy—and considerably more. In thinking of Chaucer's women, for instance, we are apt to stress those daughters of the flesh, the Wife of Bath and the trollops of the "churls' tales," and to forget the noble and gracious Blanche the Duchess, the gentle ladies in the "Legend of Good Women," the long-suffering Constance and Griselda, so glorious in their love of their husbands and children, and the fascinating Criseyde. These are much more the typical Chaucerian heroines. And they are all women of charm, tender-hearted and gracious.

Chaucer is not a satirist because he is not a reformer. His method is often satirical, but that is only a way of having fun; it is part of his laughter, his zest for life. And here we come upon what is perhaps Chaucer's most distinguishing characteristic, his glad acceptance of life. In no English poet save Shakespeare is there so much fulness of life. That is why this medieval poet, born six hundred years ago, is still an inspiration and a joy, and why, in spite of his remoteness in time, he seems so near to us in spirit.

PERCY V. D. SHELLY[1]

THE AMERICAN ASSOCIATION RETURNS TO ITS BIRTHPLACE

FROM December 27 to January 2 the American Association for the Advancement of Science will hold its annual meeting in Philadelphia, the place of its birth on September 20, 1848, a little more than ninety-two years ago. In 1848 there were 461 members of the association; now there are about 21,000, of whom nearly 500 are residents of Philadelphia. From its beginning the association has had members from all parts of the United States; now it has members residing in seventy foreign countries.

Philadelphia has been the birthplace of other scientific and cultural organizations and institutions. First on the list is the University of Pennsylvania, which grew out of the "Charity School" established in 1740 and which this year is celebrating its two-hundredth anniversary. It is now one of the great universities of our land, with more than 1,500 officers of instruction and nearly 16,000 students.

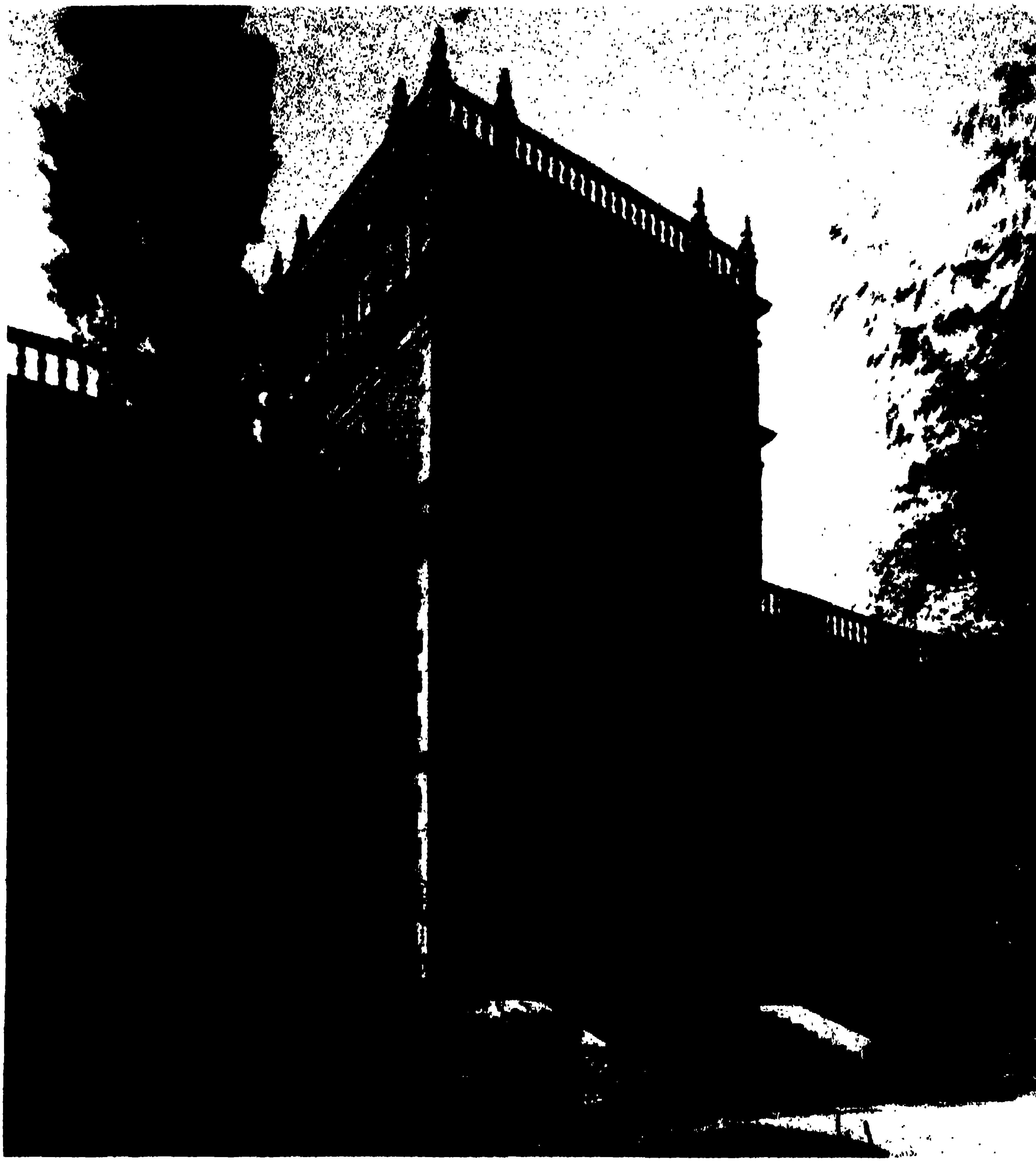
[1] Author of "The Living Chaucer." Philadelphia: University of Pennsylvania Press. 1940.

ORIGINAL BUILDINGS OF THE UNIVERSITY OF PENNSYLVANIA

AT FOURTH AND ARCH STREETS, PHILADELPHIA, AS THEY APPEARED ABOUT 1770. THE UNIVERSITY, WHICH WAS FOUNDED BY BENJAMIN FRANKLIN, WAS THEN KNOWN AS THE ACADEMY. THE BUILDING AT THE LEFT (WITH STEEPLE) WAS BUILT IN 1740 AS THE HOME OF THE CHARITY SCHOOL, TO WHICH THE ACADEMY SUCCEEDED. AT THE RIGHT IS THE DORMITORY BUILDING ADDED IN 1762. (FROM A PAINTING BY CHARLES M. LEFFERTS IN 1913.)

The second of the great institutions born in Philadelphia is The American Philosophical Society, which was organized by Benjamin Franklin in 1743 as an informal group of "lovers of wisdom"; in 1780 it secured a charter and became a formal and permanent organization. The Academy of Natural Sciences of Philadelphia was founded in 1812; The Franklin Institute in 1824; the Delaware County Institute of Science in 1833; and the Wagner Free Institute of Science in 1847. There are also several educational institutions of distinction in Philadelphia and suburbs, such as Haverford College, Swarthmore College, Temple University and Drexel Hill Institute of Technology.

Philadelphia is also noted for its amateur scientific organizations and the cultural means it provides for adults. A recent survey under the supervision of The American Philosophical Society reveals the fact that in the city there are now 287 active amateur scientific organizations with a total membership of more than 32,000 persons. The special interests of these societies lie in many fields of science—astronomy, botany, earth sciences, microscopy, ornithology, conservation, photography, etc. There are available for the use of the members of these societies and other interested persons 72 "institutes, libraries, observatories and similar science facilities." There are, indeed, six astronomical observatories in Philadelphia and its suburbs, as well as the Fels Planetarium of The Franklin Institute. If an adult resident of Philadelphia desires to enter upon formal study, he will find that he may choose from 120 courses in 19 different fields of science. In addition to the facilities for the advancement of science provided by the universities, colleges, institutes, museums and libraries of Philadelphia,



THE SCHOOL OF MEDICINE OF THE UNIVERSITY OF PENNSYLVANIA

FOUNDED IN 1765, IT WAS THE FIRST UNIVERSITY SCHOOL OF MEDICINE IN AMERICA. THERE WAS ALSO ESTABLISHED AT THIS UNIVERSITY IN 1769 AMERICA'S FIRST FORMAL PROFESSORSHIP OF CHEMISTRY. BENJAMIN RUSH, ONE OF THE FOUR FOUNDERS OF THE SCHOOL OF MEDICINE, WAS THE FIRST INCUMBENT OF THE CHAIR.

there are 94 research laboratories maintained by its great industries.

Philadelphia is indeed a distinguished city with a long and glorious past. The statue of William Penn, its founder, looks down upon its central business district from above the City Hall. It was in Independence Hall that the Declaration of Independence was signed in 1776, and there rests the famous Liberty Bell. This city was the capital of the United States under the Articles of Confederation from 1781 to 1789, and under the Constitution from 1790 to 1800. In

it was established the first public school in America, the first public library, the first bank, the first insurance company, the first law school, the first university medical college for men and for women, the first college of pharmacy and the first municipal water system. Here Benjamin Franklin drew electricity from the clouds with his kite, and here Betsy Ross made our first national flag. The old churches whisper of Sir Christopher Wren. On every hand are reminders of peace-loving William Penn and colonial days, of Benjamin Franklin, the universal genius and of the stirring events attending the birth and early days of the Republic. Here is tradition without snobbery, quality without ostentation. Even where time is taking its inevitable toll there is an enveloping air of lavender gentility.

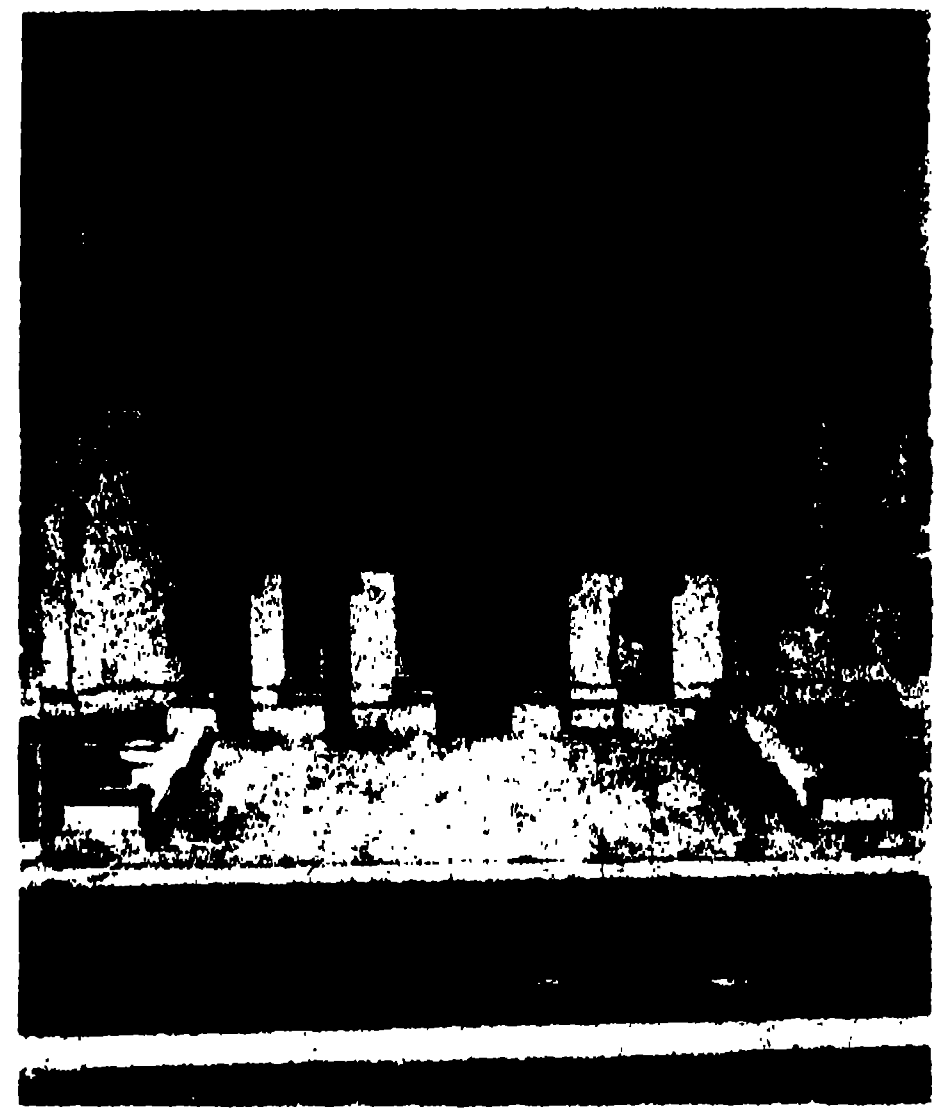
In many respects Pennsylvania is the most ideally typical American state. Its climate is neither extremely cold nor enervatingly warm. Its commerce has direct access to the sea and to the great rivers of the Mississippi valley. It has fertile soils, and 15,000 square miles of its area are underlain by coal. The Swedes established, in 1643, the first permanent white settlement within its borders. They were followed by the gentle Quakers, who were predominant in Revolutionary Days. There came, also, Dutch and Germans and, in later days, all the other hardy European stocks that have worked in our mines and manufacturing industries. It faced the realities of war in the struggle of the American colonies for independence, for the battles of the Brandywine, Paoli and Germantown were fought on its soil, and Philadelphia was occupied by British soldiers from September 26, 1777, to June 18, 1778. Washington's ragged troops suffered at Valley Forge through the winter of 1777–78, and what is regarded as the decisive battle of the Civil War was fought at Gettysburg on July 1–July 3, 1863.

Many factors have transformed Pennsylvania from a wilderness to what it is to-day. Among them are its location, its abundant natural resources, the fine qualities of the peoples who settled it. But these factors alone could not have made Pennsylvania one of the greatest manufacturing regions in the world. It has been science and its applications that have produced this amazing transformation, which is quite unparalleled in the history of mankind until our day. Science has added immeasurably to our comforts, and it has largely protected us from the ravages of infectious diseases, and, alas, it is also being used for destructive purposes. But the programs of the meeting of the American Association in Philadelphia will be devoted to the constructive applications of science. For example, the chemists will have a program on applications of chemistry to agriculture and physiology; the medical section will present a three-day program of 39 papers on malaria; and the American Philosophical Association will present a symposium on the nature of man. Altogether more than 2,000 addresses and papers will be included in the general program of the association for its Philadelphia meeting.

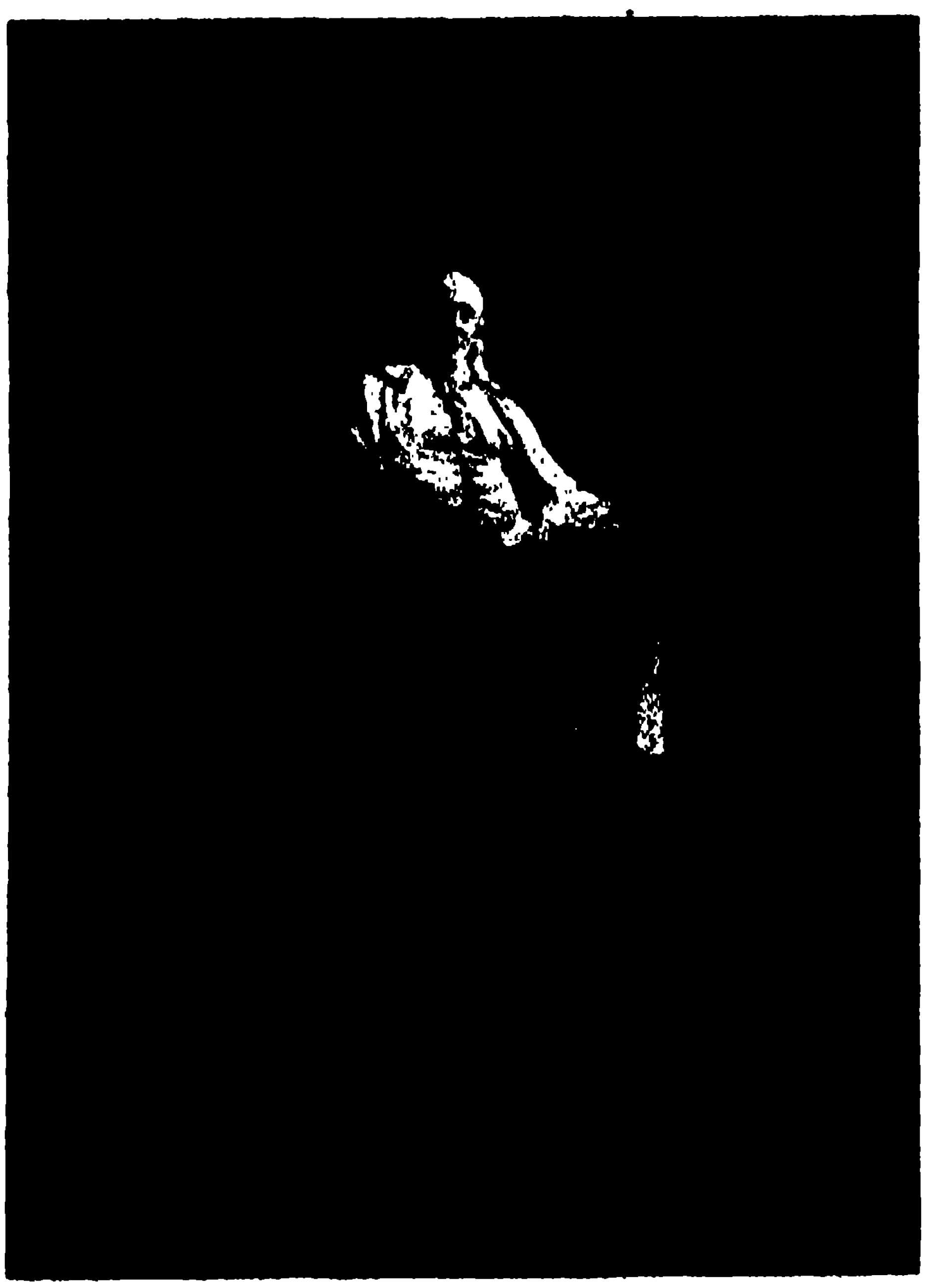
Although most of the programs of the association at Philadelphia will be for specialists, a number of them will be non-technical and open to the general public. First of these is the address of the retiring president of the association, Dr. Walter B. Cannon, of Harvard University. Another is by Dr. Edmund Ezra Day, distinguished president of Cornell University, who will deliver an address on the timely subject, "Discipline of Free Men." The annual Sigma Xi lecture will be by Dr. A. J. Carlson, of the University of Chicago, on "Science versus Life." Walter Lippmann, noted editor, author and columnist, will deliver the annual Phi Beta Kappa address on a subject that remains to be announced. In addition, there will be

scores of special programs ranging over the fields of the physical, biological, psychological, anthropological, engineering, medical, historical and pedagogical sciences that will be attractive to amateurs. Finally, there will be a science exhibit showing many of the latest investigations, the apparatus and equipment now available for scientific research, and the most recent scientific books.

But professional and amateur scientists will not be the only persons who will learn of the discoveries and progress of science announced at the meeting of the association, for skilled science writers will interpret them in hundreds of clearly and accurately written articles that will be published in the daily press. And why shouldn't the general public be interested in science? Nothing else has so profoundly affected the lives of human beings or will probably so greatly influence them in the future. In order that science shall be used wisely for the advancement of civilization it is necessary that men and women generally shall comprehend its supreme importance, not primarily because of its astounding technological applications, but more especially because of the inspiring picture it paints of the nature of the cosmos and of man.



ENTRANCE OF FRANKLIN INSTITUTE



STATUE OF BENJAMIN FRANKLIN
OF HEROIC PROPORTIONS IN THE FRANKLIN INSTITUTE.

F. R. MOULTON

THE COLLAPSE OF THE TACOMA NARROWS BRIDGE

As the Tacoma Narrows suspension bridge neared completion last spring it became apparent that it possessed some characteristics hitherto not encountered in suspension bridges. These differences took the form of marked vertical undulations which occurred under the action of wind. Continual observation indicated that this motion might occur in wind velocities as low as 4 miles per hour if the direction was favorable, and prior to the collapse of the bridge on

November 7 such motion had been noted in wind velocities up to 49 miles per hour.

These vertical undulations developed in several patterns corresponding to various natural frequencies of the structure. The lowest frequency observed was 8 cycles per minute when the main span had on it a single wave. The most violent motion noted prior to the final catastrophic one was at a frequency of 36 cycles per minute, involving ten waves on the main span.

Careful observation had indicated that this motion, which was by no means continuous, was causing no immediate damage; but it was considered advisable to modify the bridge in view of the possibility of very much stronger winds in this locality.

Early in the investigation of this structure it was suspected that the aerodynamic characteristics of the suspended portion of the structure might reveal the source of the trouble. Thus a 1/20 scale wind tunnel model representing 160 feet of the roadway section was constructed with faithful attention to detail. Subsequent tests in the 12-foot wind tunnel at the University of Washington disclosed a condition of serious aerodynamic instability sufficient to account for all the motions so far observed on the bridge. The crowding of the wind tunnel with National Defense problems from the Pacific Coast slowed up

Courtesy of Bashford and Thompson, Tacoma.

TACOMA NARROWS BRIDGE IN VIOLENT WAVE MOTION

THE TWO CABLES FROM WHICH THE BRIDGE IS SUSPENDED EXPERIENCED VERTICAL OSCILLATIONS OF AS MUCH AS 28 FEET WITH CYCLES A LITTLE OVER 4 SECONDS. THE DESTRUCTIVE FORCES WERE INCREASED BY THE FACT THAT THE WAVES IN THE TWO CABLES WERE OUT OF PHASE, THE TOP OF THE WAVE IN ONE CABLE OCCURRING WHEN THE OTHER ONE WAS AT NORMAL POSITION.

Courtesy of Bashford and Thompson, Tacoma.

TWO HUNDRED FEET OF THE TACOMA BRIDGE PLUNGING INTO THE SOUND

FOLLOWING WHICH THE AGITATION BECAME SO VIOLENT THAT THE REMAINDER OF THE 2,800 FEET SPAN FOLLOWED IT WITHIN A FEW MINUTES. WITH THE REMOVAL OF THE LOAD FROM THE CABLES OVER THE CENTRAL SPAN THE TENSION SHOREWARD BECAME SO GREAT THAT THE TOWERS WERE BENT BEYOND THEIR ELASTIC LIMITS AND THE SPANS FROM THE TOWERS TO THE SHORES SAGGED 25 TO 30 FEET, BUT DID NOT FALL.

further testing of devices calculated to improve the aerodynamic characteristics of the structure. Finally, on November 2, a number of tests were completed from which arose a whole series of proposals for the stabilization of the bridge.

However, five days after completion of these tests and before contracts could be let covering the installation of the chosen corrective device the bridge collapsed in a 42-mile wind.

Shortly before 10:00 A.M. on the morning of November 7 the bridge was observed to be moving in characteristic vertical motion with a frequency of 36 cycles per minute and a very moderate amplitude. Traffic was still crossing the span, when without any warning this motion changed instantly to a frequency of 14 cycles per minute with a single node at the center of the span; but for the first time in its history the two cables were not in step. The motion of the two cables being 90 degrees out of phase with each other a violent twisting motion was imparted to the structure which persisted until its ultimate destruction shortly after 11:00 A.M.

This twisting of the structure was confined to the main span, since the side spans were restrained by check reins installed several hundred feet out in the side spans. But in the main span at times the degree of twist surpassed 90

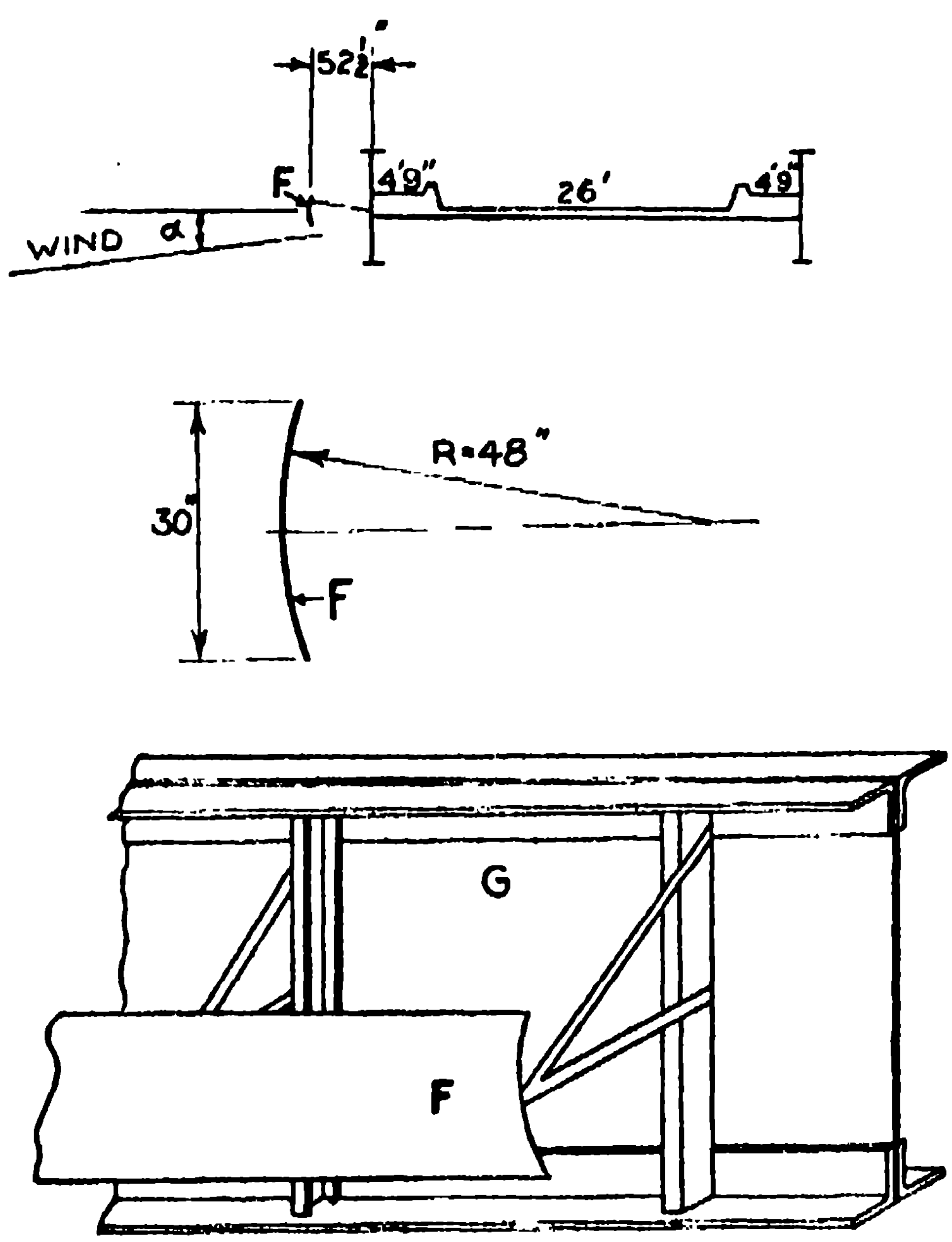
degrees and the lamp posts at the two quarter points actually crossed at right angles as one sighted along the curb. The acceleration at times appeared to exceed that of gravity and the extreme motion at the edge of the sidewalk was in excess of 28 feet vertically, with the cycle complete in a little over 4 seconds. At all times the motion appeared to be more severe at the west side of the main span, since it was in this region that a number of the lamp posts were torn from their foundations and thrown across the deck and it was at this point that the first failure in the girder and suspenders took place.

During this motion, which was responsible for the gradual disintegration of the structure, careful observations were taken out to well beyond the quarter point on the main span. Briefly, it appears that the lateral bracing system in the deck failed first; this was followed by a buckling failure in the stiffening girder at about the west quarter point in the main span; presently a series of suspenders on the north side near this same buckling failure let go and the first section of the suspended structure, about 200 feet long, fell into the sound.

The removal of this large amount of weight so agitated the remaining portion of the bridge that it was only a matter of minutes till the whole 2,800 feet comprising the main span had torn loose and plunged into the water. At the same time the side spans sagged 25 or 30 feet and suffered considerable damage but did not tear loose; while the two tower tops were forced so far shoreward that the elastic limit of the steel was exceeded on both tension and compression sides,

TACOMA NARROWS BRIDGE MODEL AT THE UNIVERSITY OF WASHINGTON

PROFESSOR FARQUHARSON DEMONSTRATING THE METHOD USED TO MEASURE CHANGING STRESSES ON THE MODEL.



PROPOSED "FAIRING DEVICE"
Top: CROSS SECTION OF BRIDGE. *Middle:* FAIRING DEVICE. *Bottom:* SIDE VIEW OF SOLID PLATE GIRDER, *G*, AND THE PROPOSED FAIRING DEVICE, *F*.

leaving those members permanently distorted.

The basic source of the trouble with this structure seems to have been in the stiffening girder itself. This is one of two major bridges on which stiffening has been accomplished through solid plate girders instead of the more conventional open truss, and it is of extreme significance that this undulating motion has developed on both of these bridges. Nothing short of complete aerodynamic studies conducted on the many types of suspension bridges now in use could conclusively prove the point, but one might hazard the guess that had the Golden Gate bridge been built with solid plate girder stiffening members the same undulating motion would have occurred.

It seems reasonably certain that had time permitted the installation of the very simple fairing device shown in the accompanying illustration this catastrophic motion would never have developed and the Tacoma Narrows bridge would still stand as the third longest span in the world.

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Associate Professor,
Civil Engineering
UNIVERSITY OF WASHINGTON

TACOMA NARROWS BRIDGE—STATISTICAL DATA

THE Tacoma Narrows suspension bridge was approved as a PWA project and allotment made June 23, 1938. The original grant was for $2,700,000 toward an estimated construction cost of $6,000,000. Two subsequent amendatory applications filed by the applicant, The Washington State Toll Bridge Authority of Olympia, raised the grant to a final figure of $2,964,150 toward an estimated construction cost of $6,587,000.

The bridge consisted of a suspension structure having a total length of 5,000 feet, divided by a central span of 2,800 feet and a span on either side of 1,100 feet. With approaches and anchorages, the structure presented an over-all length of 5,539 feet, containing a two-lane concrete roadway 26 feet wide flanked on either side by a 4 foot 9 inch sidewalk. For navigation a minimum vertical clearance of 196 feet was provided. The central span of 2,800 feet was exceeded by only two others—the 3,600 foot central span of the George Washington Bridge in New York City and the 4,200 foot central span of the Golden Gate Bridge at San Francisco. The two main towers, each 425 feet high, marked a major advance in suspension bridge design. They are what is known as "flexible" towers and although rigidly anchored in concrete caissons, the top of the towers could be moved as much as 5 feet in the direction of the longitudinal axis of the bridge in either direction.

Girders, floor beams and stringers for the floor were brought by water from Pennsylvania to the bridge site, assembled on barges into complete sections of roadway and lifted into place by travelers mounted and traveling on the main cables.

Each of the steel towers contains 3,750,000 pounds of structural steel and the cost of each is approximately $250,000. The two main cables supporting the central span were 17½ inches in diameter and consisted of 6,300 parallel wires and from anchorage to anchorage were 5,772 feet in length.

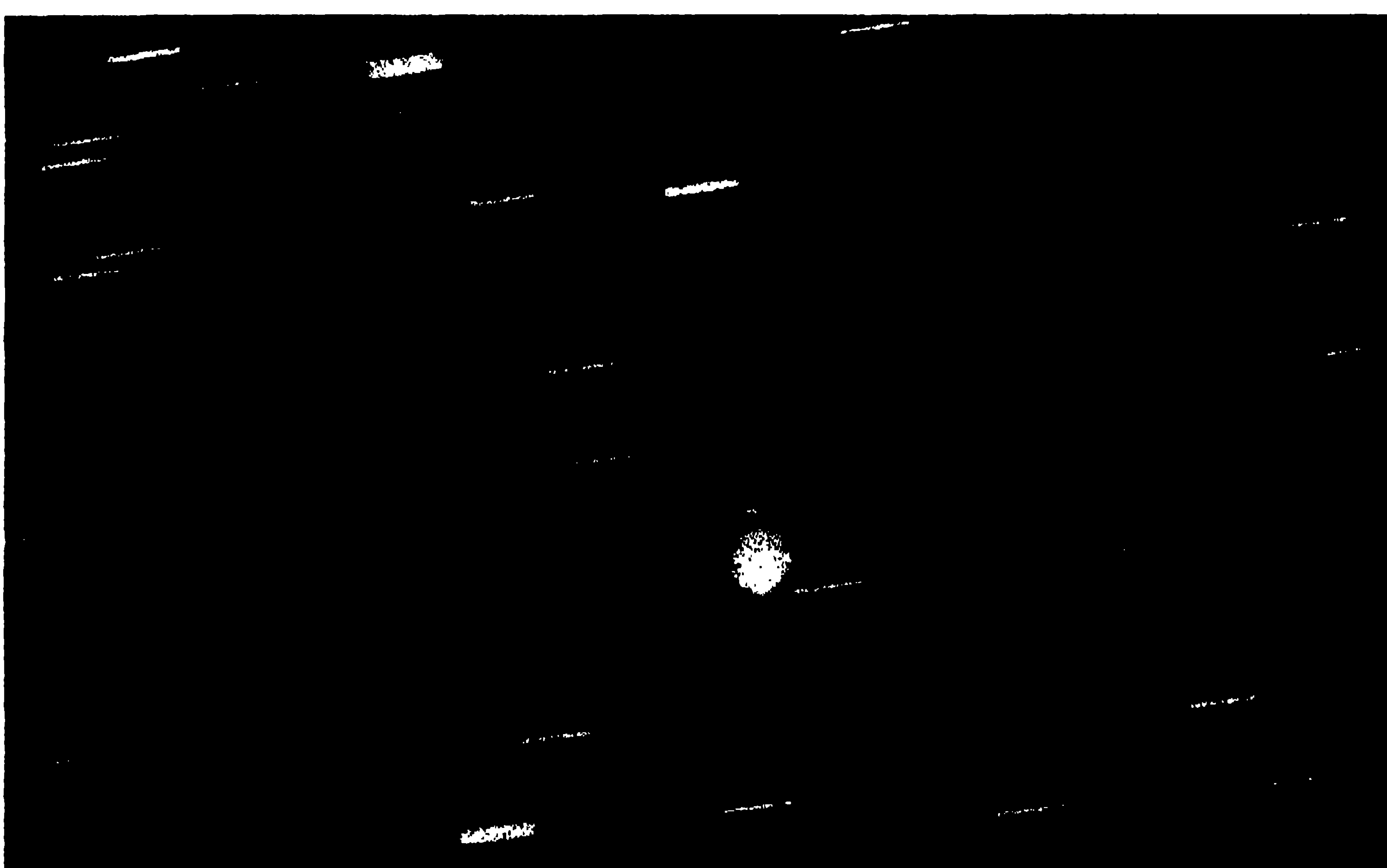
The project was completed in 19 months, a record in bridge construction, and was dedicated and opened to the public on July 1, 1940.

COMETS OF 1940

ALTHOUGH the crop of comets in 1940 has been very mediocre in number, the occurrence of one rare specimen has more than compensated for the scarcity. Comet Cunningham, the third to be discovered in 1940, shows promise of becoming the brightest and most thoroughly observed comet in many years. By the end of this year it should be fairly conspicuous to the naked eye and by the middle of January, 1941, should be very bright but too far south for observation from northern latitudes.

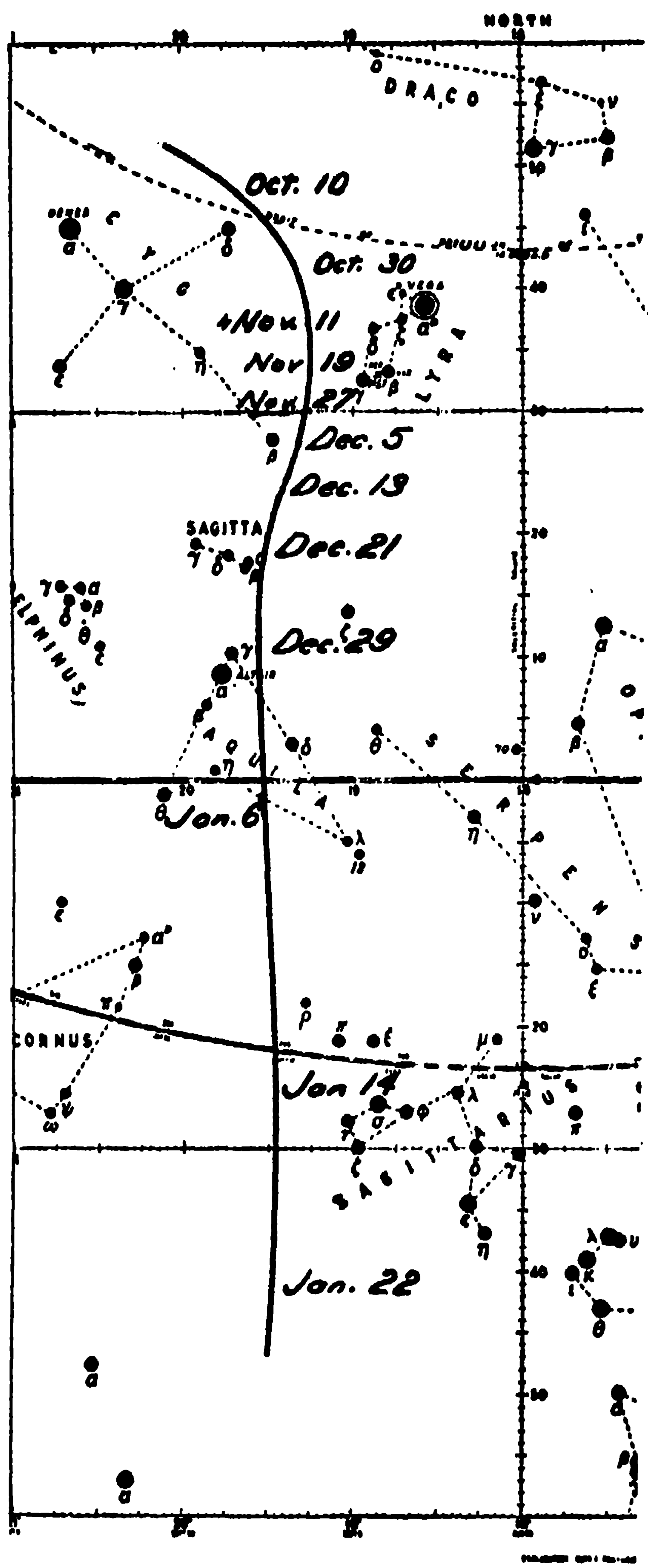
The first eight months of 1940 were distinguished by the discovery of no comets, except for one case in which an object thought at first to be a comet was finally classified as an asteroid. The first confirmed discovery came on September 1, when L. E. Cunningham, of the Harvard Observatory, found comet 1933f in the position predicted for its return by Dr. G. G. Cillié and W. A. Johnson, both at Harvard when the calculations were made. This faint periodic comet is particularly a Harvard possession, because it was originally discovered by the writer in 1933. At this return, its first since it was last observed in January, 1935, by Dr. H. M. Jeffers, of the Lick Observatory, comet 1933f is only six hours off schedule. The error is slightly greater than one part in ten thousand of the period of revolution about the sun. The period is the least certain of the orbital elements. Comet 1933f is chiefly of interest because of the low eccentricity of its orbit, only 0.35.

Two weeks after his premeditated rediscovery of comet 1933f Mr. Cunningham discovered a new comet, 1940c, while searching the Harvard plates. It is 1940c that stands out as the colossus of the 1940 harvest of comets. In Septem-



COMET CUNNINGHAM, SOON TO BE VISIBLE WITH THE UNAIDED EYE

PHOTOGRAPHED OCTOBER 25, 1940, WITH THE 16-INCH HARVARD COLLEGE OBSERVATORY TELESCOPE. SINCE THE TELESCOPE FOLLOWED THE COMET WHICH WAS MOVING WITH RESPECT TO THE STARS, THE STAR IMAGES DRIFTED ON THE PLATE, PRODUCING STREAKS.



PATH OF COMET CUNNINGHAM IN 1940 AND JANUARY, 1941.

ber it was quite faint (13^m) but was about two and a half times the earth's distance from the sun. At this distance only comets that are intrinsically very large can be observed and they are rarely discovered so far away. Calculations indicate that Comet Cunningham should increase from its discovery brightness by a factor of nearly a million times, as seen from the earth. So far (early November) the predicted increase of nearly a hundred-fold is observed and there is little question that the comet will live up to expectations. Most of the calculated increase arises from the remarkable fashion in which comets brighten as they approach the sun. Instead of obeying an inverse-square law in the distance, they are apt to follow even an inverse-sixth-power law, although no general equation can follow accurately the perverse light variations of a comet.

A recent photograph of comet 1940c (exposed by Mr. Cunningham) is reproduced here. A chart of the predicted path is also shown for the convenience of those who may wish to observe the comet. The solid curve represents the apparent path and the dates show the positions along the path. For those who wish merely to see the comet I suggest that no attempt be made until late in December when the moon has left the evening sky. Comet Cunningham should be easily visible with the naked eye in the early evening after the sky becomes moderately dark. Look west or a little north of west a few degrees above the horizon. In cities where the sky is artificially illuminated the comet may still be difficult to see, but in country areas it should be fairly conspicuous. In early January before the moon has again become bright, the comet should be as conspicuous as the brightest stars, but will have moved farther south. By the middle of January it will be too far south for observation from most of North America.

Another new comet, 1940d, was photographed on the Harvard patrol plates in early August but was not detected until late September, when the present writer was searching the plates of that period. By the time of the actual discovery the comet had moved into the southern sky near the South Pole, but was found by

Dr. Bobone, at Cordoba, Argentine, near the position predicted by Dr. A. D. Maxwell and by the writer. Early in October Dr. J. S. Paraskevopoulos, superintendent of the Harvard Station in Bloemfontein, South Africa, independently discovered the comet on plates taken there. Announcement of the previous discovery had not reached him, presumably because of war conditions.

It is worthy of comment that comet 1940d was discoverable at Harvard only because the European asteroid observers and visual observers were inactive. In early August the comet passed through the center of the asteroid region, near the ecliptic at opposition to the sun. Ordinarily it would have been found and announced immediately before there was a chance of finding it on plates taken with the small patrol cameras. Comet 1940d will not again be observable from the latitude of Cambridge, but is still fairly bright photographically in the south, although several times too faint for the naked eye.

The periods of revolution about the sun for both comets, 1940c and 1940d, are probably too great for either to be observed at a future return by any one living to-day.

The last comet so far reported in 1940 was observed in early October by Okabayasi, a Japanese astronomer near Tokyo. It was then not far from the sun in the sky and already past perihelion. It is now faint, about the twelfth magnitude, and will continue to fade in brightness. The motion about the sun is retrograde, according to orbit calculations by Miss Scott at the University of California and by Dr. A. D. Maxwell and F. J. Wood at the University of Michigan. It is probable, therefore, that the period of revolution about the sun is a great many years.

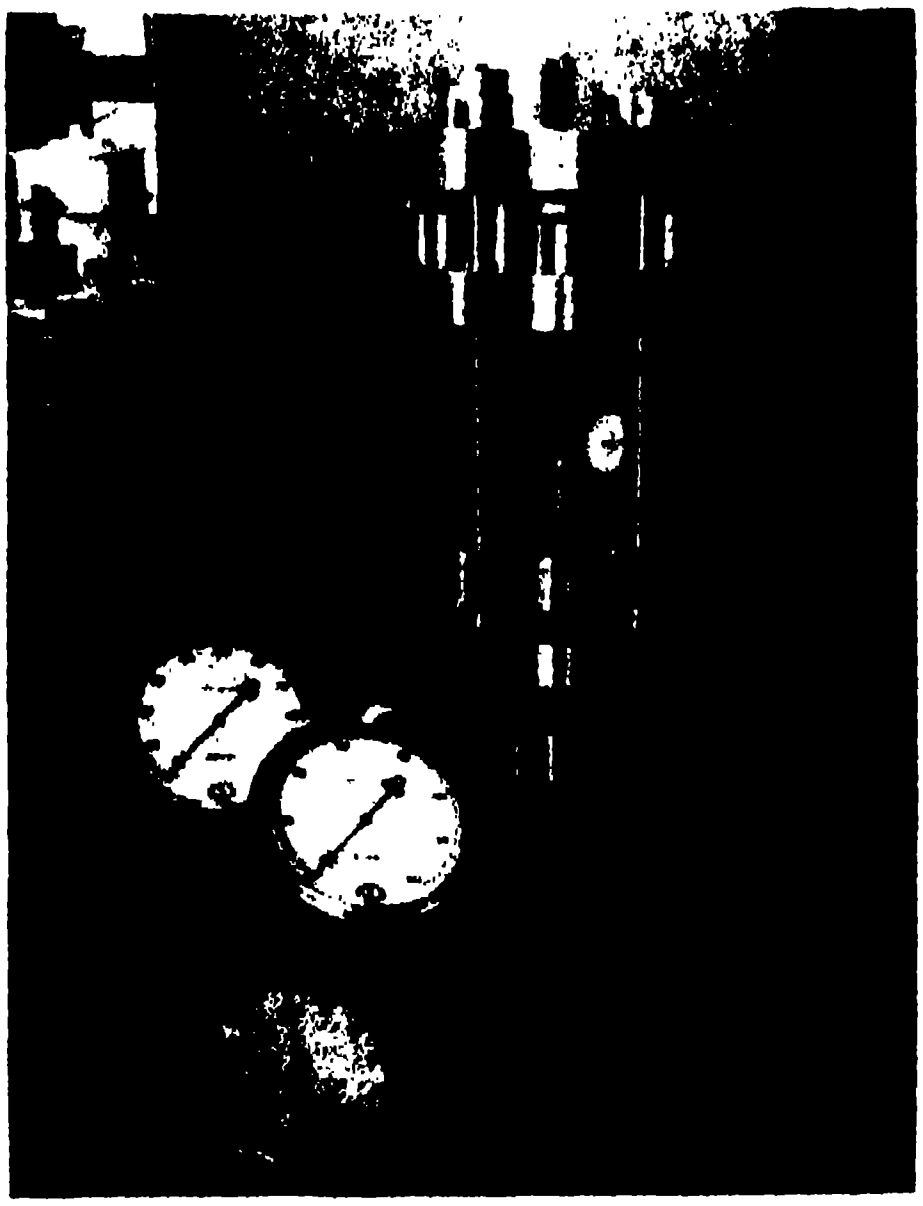
Besides the general interest and astronomical importance of the bright comet discovered by Cunningham, perhaps the most unusual feature of the four 1940 comets is the fact that they were all discovered within a period of only five weeks.

Fred L. Whipple
Harvard College Observatory

THE ANNUAL EXHIBITION OF THE CARNEGIE INSTITUTION

Beginning on Saturday, December 14, and continuing on Sunday and Monday, the Carnegie Institution of Washington again holds open house for the public in its Administration Building at Sixteenth and P Streets, N. W., Washington, D. C. At this time various departments and laboratories of the institution will have on display exhibits illustrating some of their recent work.

Although a considerable part of the facilities and effort of the institution is at present directed to problems relating to national defense, yet as much as possible of the basic research, upon which the future of science rests, is being continued. In pursuing this course, the Geophysical Laboratory, with the cooperation of the Department of Terrestrial Magnetism, has undertaken the construction of an apparatus to produce extremely high pressures, in the neighborhood of three million pounds per square inch. A pressure of this magnitude corresponds to that found at a depth of 300 miles below the surface of the earth. It thus becomes possible to study in the laboratory the behavior of metals and minerals under such extreme conditions as are found in the earth's interior. One result already obtained with this apparatus is of great interest in the study of terrestrial magnetism, for it has been found that high pressures counteract the tendency of some ferromagnetic substances to lose their magnetism at high temperatures. Accordingly, it is possible that part of the earth's magnetism can be accounted for by the presence in its interior of materials which



APPARATUS FOR EXTREME PRESSURES

retain their magnetic properties in spite of the high temperatures prevailing there. The Geophysical Laboratory will have an exhibit showing some of the applications of this apparatus.

Another interesting exhibit will be that of the Division of Plant Biology, offering paleobotanical evidence indicating large-scale climatic changes in the Pacific Northwest during recent geologic ages. This has resulted in the southward migration of the old forests and their replacement by new types of trees.

One of the most complete records of the plant life of the past 50 million years to be found anywhere is preserved in the fossil deposits of the John Day Basin in Oregon. This record shows a gradual change from the large, heavy leaves of a subtropical forest living in this region during the Eocene period 50 million years ago to the present-day vegetation. Included in this exhibit will be specimens of leaves of the fossil plants from the John Day Basin and leaves from their living relatives now found much farther to the south, arranged to show the slow change of the Oregon forests and their movement southward.

The Department of Genetics will have an exhibit on the gene, the extremely small units, which are the carriers of hereditary characteristics, found in the chromosomes of the cells. The exhibit of this department will show the correlation between the bands found on the chromosomes of the fruit-fly (Drosophila) and the positions of the genes.

There are genetic experiments with the fruit-fly which can be easily performed by students in the high-school laboratory. The department has prepared a booklet describing these experiments and has also arranged to supply the schools with fruit-flies. The exhibit will illustrate this educational work.

At the time of the exhibition there will also be a showing of two other sets of pictures; one a diversified series of water colors portraying the Aztec god Xipe Totec, the second a series of photographs of active volcanos, including Stromboli, Vesuvius, Etna and Pelée. During the past summer this latter series was shown at the World's Fair in New York.

The Mount Wilson Observatory will have an exhibit consisting of photographs and charts illustrating new developments in the study of supernovae. These are the stars which, for some reason we do not yet understand, suddenly "blow up." Their size and their light output increase tremendously in a very short time, then they slowly fade away, until they are at last lost to our view in the depths of space.

On the evening of December 10, Dr. Edwin Hubble of the observatory will give a public lecture on these strange stars. In addition, as has been the custom in the past, short lectures based on the material of the exhibits will be given during the course of the annual exhibition.

G. B. H.

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